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SURGICAL LESIONS OF THE ESOPHAGUS SEEN IN AN ARMY THORACIC SURGERY CENTER

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DURING the past three years, 133 patients with diseases and injuries of the esophagus have been treated at this army thoracic surgery center. This series represents mainly the nonmalignant conditions, for very few patients in the younger age group have carcinomas. The purpose of this paper is the presentation of the treatment employed. Forty-two esophageal operations were performed by the staff with only one operative mortality, an incidence of 2.4 per cent. This mortality occurred following the local excision of a benign tumor. The other patients were treated by instrumental dilatation, conservative measures, or did not require treatment. The esophageal conditions treated and the operations performed are tabulated in Tables I and II. No attempt will be made to discuss the preoperative and postoperative management. The potential dangers of esophageal surgery associated with the inherent anatomic characteristics of the esophagus, the virulence of the bacterial flora resulting from stasis, and the poor general condition of the patient caused by his inability to eat were well appreciated and adequate preoperative measures were employed.

STRICTURE

Twenty-seven patients had cicatricial stenoses, fourteen of which were due to consumption of a caustic fluid. In eleven of these the caustic was contained in sabotaged alcoholic beverages and consumed accidentally overseas. The other three resulted from suicide attempts. Six patients had stenoses secondary to war wounds of the esophagus. A congenital short esophagus was complicated by ulceration, scarring, and stenosis at the esophagogastric junction in three patients. Three were secondary to an esophagitis. One resulted from local ulceration and constriction due to a foreign body.

From the Section of Thoracic Surgery, Kennedy General Hospital, Memphis, Tenn.
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TABLE I. CLASSIFICATION OF 133 ESOPHAGEAL CONDITIONS SEEN IN A THORACIC SURGERY CENTER

TYPES	NO.	TREATMENT	NO.
Strictures:			
Caustic	14	Intrathoracic esophagoplasties	4
Congenital short esophagus	3	Antethoracic esophagoplasty	2
Traumatic	6	Repeated esophageal dilatations	21
Esophagitis with stenosis	4		27
	27		
Tumors:			
Benign: neurofibroma	1	Local excision	3
leiomyoma	2	Resection with anastomosis	2
Malignant: adenocarcinoma	4	Inoperable (exploratory)	3
squamous cell carcinoma	1	Total gastrectomy, transverse colectomy and esophagojejunostomy	1
adenocarcinoma (stomach)	1		9
	9		
Cysts:			
Dermoid	2	Transthoracic esophageal resection with esophagogastric anastomosis	1
Simple	2	Local excision	4
Bronchogenic	1		5
	5		
Diverticulum:			
Traction	4	No treatment indicated	8
Pulsion	3	Transpleural diverticulectomy	1
Epiphrenic	2		9
	9		
Traumatic injuries, war wounds:			
Tracheoesophageal fistula	1		
Esophagocutaneous fistula	3		
Mediastinal and paraesophageal abscesses	6	Drainage of paraesophageal abscesses	5
Paraesophageal shell fragments	8	Removal of shell fragments	6
	18		11
Varices:	1	Too extensive for treatment	
Cardiospasm:	20	Cardioplasties	11
		Dilatations	9
			20
Congenital short esophagus:			
Carcinoma	1	Resection with anastomosis	1
Stricture	3	Required dilatations	3
Ulcer	4	Temporary neuremphraxis	3
Essentially asymptomatic	6	Fixation of diaphragm above esophagogastric junction	1
Symptoms improved by modified ulcer regimen	6	No surgical treatment	12
	20		20
Hiatal hernia:	9	Required repair of hernias	5
Paraesophageal hernia:	4	Required repair of hernias	1
Extrinsic esophageal obstruction: (tumors, cysts, aneurysms, tuberculous nodes)	11	No treatment directed to the esophagus	
Total	133		

Instrumental dilatation over a previously swallowed thread as a guide was effective in twenty-one patients. This was impossible or ineffectual in six patients and surgical therapy was employed. The degree of stricture in three patients was too great to allow instrumentation. Two others had upon admission strictures associated with mediastinitis and multiple fistulas incurred accidentally during previous attempts at instrumental dilatation. Instrumentation

TABLE II. ESOPHAGEAL OPERATIVE PROCEDURES

TYPE	NO.	MORTALITY
Cardioplasty	11	0
Reconstructive transthoracic resection and esophagogastric anastomosis	7	0
Reconstructive antethoracic esophagodermatojejunal anastomosis	2	0
Transthoracic total gastrectomy, transverse colectomy and esophagojejunostomy	1	0
Esophagostomy	2	0
Transthoracic diverticulectomy and fixation of diaphragmatic hiatus above esophagogastric junction (congenital short esophagus)	1	0
Excision of intramural tumors and cysts	7	1
Drainage of paraesophageal abscesses	5	0
Removal of paraesophageal foreign bodies (shell fragments)	6	0
Total	42	1

in another patient was possible but not effective. Reconstructive operations were necessary in these six patients. Four intrathoracic esophagoplasties and two antethoracic jejunodermatoesophagoplasties were performed. The third stage in one of the latter patients has not been performed as yet. For the intrathoracic esophagoplasties, a tube was fashioned from the greater curvature of the stomach. The blood supply for this tube was furnished primarily by the right gastroepiploic artery. One of the intrathoracic esophagoplasties was total, the anastomosis being just within the thoracic inlet; another was approximately one inch below the thoracic inlet, and the other two were at the level of the aortic arch.

For contemplated intrathoracic esophagogastric anastomosis near the thoracic inlet, adequate exposure was felt to be best obtained by using first an abdominal incision for the mobilization of the stomach and construction of the gastric tube and then a high thoracic incision for formation of the anastomosis. When the contemplated anastomosis is at the level of the aortic arch or below, adequate exposure can be obtained by a single transthoracic approach.

The antethoracic esophagoplasties were performed in three successive stages at three-week intervals. In the first patient the esophagus was transected transthoracically just proximal to the stricture and brought out through a cervical incision as an esophagostomy. The second stage consisted of formation of a jejunal tube. Sufficient jejunum was mobilized to reach easily to the neck to allow esophagojejunal anastomosis, but during the preparation of inserting the jejunal tube beneath the skin of the chest wall one of the primary arcuate arteries was torn and eight inches of the jejunum had to be sacrificed. The esophagus and the jejunum were then joined by a skin tube at the third stage.

The functional results following both the intrathoracic and antethoracic esophagoplasties have been entirely satisfactory. The patients are able to eat regular diets with no difficulty, although the patients with the antethoracic esophagoplasty must chew their food more thoroughly and more time is required for the passage of food through the tube.

If a reconstructive operation is contemplated, and the condition of the patient is such that supplementary feedings are necessary, the decision as to a

gastrostomy or jejunostomy should rest with the surgeon performing the latter operation. An inconveniently located gastrostomy may prevent formation of a tube from the stomach. A jejunostomy is preferred if an intrathoracic anastomosis is contemplated.

TUMORS

There were three benign, intramural, esophageal tumors, two leiomyomas and one neurofibroma. All three arose between the submucosa and muscularis and all were removed by local excision. The mural attachment of one large leiomyoma of the upper third of the esophagus was so extensive that considerable dissection of the esophageal wall was necessary. Though this appeared viable at the termination of the operation, necrosis occurred which resulted in mediastinitis and empyema. This patient died on the fifth postoperative day.

There were five esophageal carcinomas, of which only two were operable. These patients were treated by esophageal resection and esophagogastric anastomosis. One of these patients is of interest as the lesion was an adenocarcinoma arising at the esophagogastric junction in a patient having a congenital short esophagus. A sixth patient had a large fungating carcinoma of the stomach that had infiltrated the lower esophagus, the spleen, and the transverse mesocolon. A total gastrectomy, splenectomy, and transverse colectomy were performed, followed by an esophagojejunostomy and double-barrel colostomy.

CYSTS

There were five unusual and interesting esophageal cysts. All of these were intramural and arose between the submucosa and muscularis. There were two dermoid cysts, two simple cysts, and one bronchogenic cyst. Local excision was possible in four of the five cysts, but resection of the lower esophagus including the cyst followed by an esophagogastric anastomosis was necessary in the fifth. Whenever possible, cysts and benign tumors are explored through the left pleural cavity, for if esophageal resection is found advisable, the stomach is readily available for anastomosis.

DIVERTICULA

There were four traction, three pulsion, and two epiphrenic diverticula. The traction diverticula were thought to be secondary to tuberculous mediastinitis and mediastinal lymphadenopathy in that large calcified mediastinal nodes were present in all cases. The orifices of the diverticula could be seen during esophagoscopic examinations. The mucous membrane about the orifices appeared taut but not inflamed or ulcerated. In two cases, retained barium could be demonstrated within the diverticula for several days following radiographic examinations. Faulty emptying was probably responsible for the symptoms present. In view of the fibrous mediastinitis and calcified mediastinal lymphadenopathy, no treatment directed to the esophagus was indicated.

The three pulsion diverticula of the thoracic esophagus were associated with vague complaints consisting mainly of dysphagia and night pain. No esophageal obstruction was noted roentgenographically. Night pain may have

resulted from accumulation of gastric secretion in this pouch when the patient was in the prone position. The symptoms in this group were not severe nor consistent and were improved by conservative measures including feedings or amphojel prior to retiring.

The two patients with epiphrenic diverticula had congenital short esophaguses. Both of these patients complained of epigastric and substernal pain occurring several hours after meals and especially at night. One patient also had considerable pain upon swallowing. Esophagoscopic examinations demonstrated one of the diverticula to be just below the esophagogastric junction and the other just above it. There was considerable inflammation and erosion of the mucous membrane immediately around the orifices of the diverticula. One patient was completely relieved of symptoms by a Sippy regimen and the other required excision of the diverticulum and suture of the diaphragm at a higher level about the esophagus before symptomatic relief was obtained.

TRAUMATIC INJURIES OF THE ESOPHAGUS

Traumatic injuries of the esophagus were seen in ten patients. Seven were caused by shell fragments or bullets and one by a bayonet. Two resulted from instrumental perforation during esophagoscopy elsewhere. Five of these esophageal injuries were associated with injuries of the trachea necessitating emergency tracheotomies and gastrostomies. Six patients had developed paraesophageal and mediastinal abscesses which required drainage. Residual abscesses and esophagopleural and esophagocutaneous fistulas were present in these patients upon admission. Most of these latter patients required secondary drainages and the fistulas persisted for a number of months. Another patient had an esophagotracheal fistula that healed on conservative management employing chemotherapy.

It was possible to remove the tracheotomy and gastrostomy tubes soon after the patients returned to this country. Six patients developed localized esophageal strictures that responded readily to instrumental dilatation. Two additional patients, as previously described, had upon admission esophageal strictures associated with fistulas resulting from instrumental dilatation.

Large shell fragments or bullets were in contact with the esophagus in eight patients. Two of these had caused localized fistulas or diverticula. It was felt advisable to remove the metallic foreign body in six of these patients.

ESOPHAGEAL VARICES

Only one patient with esophageal varices was seen. He had had a splenectomy five years previously with apparent symptomatic relief from bleeding. During the month prior to admission three massive hemorrhages occurred. Radiographic studies revealed extensive varices the entire length of the esophagus. The extensiveness of the varices precluded treatment.

CARDIOSPASM

Twenty patients with cardiospasm were treated. In eight patients with moderate degrees of cardiospasm satisfactory symptomatic improvement re-

sulted from instrumental dilatation though there was no evidence of reduction in the size of the esophagus afterward.

Transpleural cardioplasties were performed in eleven patients not significantly improved by instrumental dilatation. In contrast, the operative group were given more permanent and complete relief of symptoms and showed striking reductions in the size of the esophagus postoperatively. One patient is now awaiting operation.

All of the cardioplasties were performed through a transpleural approach, for it was felt that this allowed better exposure of the esophagogastric junction, better mobilization of the lower esophagus and cardia of the stomach and, in turn, the construction of a larger aperture than would be possible through an abdominal approach. The new stoma was made large enough to allow for reduction in size as the caliber of the esophagus decreased. Its size determines the ease with which the esophagus empties itself and the likelihood of its reduction in caliber. The first three cardioplasties were performed in a manner similar to a Finney type of pyloroplasty technique, and the others in a manner similar to a Heineke-Mikulicz type. The latter was found to be the easier and more satisfactory procedure.

CONGENITAL SHORT ESOPHAGUS

Twenty-three patients having a congenital short esophagus were observed. The presenting symptoms in most instances were dysphagia, painful swallowing, substernal pain, vague epigastric pain and discomfort, and night pain. One patient had a carcinoma at the esophagogastric junction, three a high-grade stricture, six an ulcer, and two were associated with epiphrenic diverticula. The others were uncomplicated. The patient with the carcinoma had an esophageal resection and esophagogastric anastomosis. The strictures responded to instrumental dilatation and a modified Sippy regimen. Three patients had temporary phrenic neuremphraxis with only partial or temporary improvement. One of the patients with an epiphrenic diverticulum was completely relieved by means of a Sippy diet. The other one was not significantly improved by this measure. The dysphagia, painful swallowing, and night pain persisted. These symptoms disappeared following a transpleural diverticulectomy and resuturing of the diaphragm to the esophagus at a higher level. The others were relieved of symptoms by carefully following a modified Sippy regimen.

Patients with a congenital short esophagus may have retention of gastric juice in the gastric pouch between the diaphragm and esophagogastric junction. This is more likely to occur when the patient is in the prone position while sleeping. The presence of the retained gastric juice may allow peptic digestion of the lower esophageal mucous membrane and be responsible for the high incidence of ulcers. Such ulcers can frequently be detected by esophagoscopic examinations when not apparent on esophagrams. Sleeping in the semiprone position may aid in emptying of the gastric juice and allay symptoms. Feedings, amphojel, or some buffer substance should be taken prior to retiring to buffer the gastric acidity.

A congenital short esophagus is occasionally misinterpreted as being a hiatal hernia, and in some patients both factors may be present. In the former condition the esophagus is taut as well as that portion of the stomach above the diaphragm, whereas in the latter condition the esophagus and stomach appear redundant.

SUMMARY

The conditions found and the treatment employed at this Army Thoracic Surgery Center in 133 patients with various lesions of the esophagus are presented. There were forty-two major esophageal operations performed by the Staff with one mortality, an incidence of 2.4 per cent. The other patients were treated either by instrumental dilatation or by conservative measures.

DISCUSSION

DR. R. H. SWEET, Boston, Mass.—This is a perfectly marvelous series of cases, and the results are certainly excellent.

This is a field in which I am particularly interested, and the paper brought to mind questions about various matters which have to do with these problems, many of the points, of course, being still controversial.

For instance, there is the matter of the incision. I have performed five esophagectomies for these stricture cases, pulling the stomach all the way up to the apex of the chest for an anastomosis. In all of these, a single thoracic incision was used. Dr. Kay does not mention whether he removed the esophagus or not. He merely speaks of it as "esophagoplasty." I would like to have him clarify that point, having felt that one should take the esophagus out below the point of anastomosis. I have always done it through a single thoracic incision.

Even though we have all had successes, such as the young man whom he showed in the pictures, external esophagoplasty is never a thoroughly satisfactory procedure, and I feel that something else better than that should be substituted, if possible.

One question, when it comes to that: Is there any evidence in Dr. Kay's experience that anastomosis or at least sutures between skin tubes and the jejunum or the stomach tend to develop strictures? They seem to do so, whereas, on the other hand, if we suture the esophagus to the skin, they do not occur. The reason for that may be that the esophageal mucosa is so much more like the skin than is the jejunal or gastric mucosa.

Then the enormous subject of cardiospasm comes to the fore. I would like to say that I have tried about every possible surgical maneuver, including the one which he describes, with excision and various cardioplastics of one sort or another. Excluding, of course, the fact that many cases of cardiospasm do not need surgery, the important point is: How long have these cases been followed? After a good deal of early encouragement, we are beginning to see some difficulties arising during the late convalescence, months and years following the procedure. In that group of cases, experience seems to favor the Heineke-Mikulicz type of procedure, of longitudinal incision and transverse suture. Results in the direct surgical approach to cardiospasm have been best when that method was used.

DR. FREDERICK R. HARPER, Denver, Colo.—In 1942, Dr. Lewis of Philadelphia and I worked on some cadavers in order to discover a suitable approach to the upper abdominal organs through the chest. We decided that an approach which involved removal of the ninth rib with extension of the incision into the abdomen and splitting the diaphragm would give the least exposure. Since I returned from overseas, I have had an opportunity to use the incision for removal of carcinomas of the cardiac end of the stomach and esophagus and also for the repair of diaphragmatic hernias. The incision has proved to be entirely satisfactory.

(Slide.) The incision is made over the ninth rib and extended for about two inches into the abdomen. The ninth rib is removed and the chest entered through its bed. The costal arch is then divided and the incision is extended for about two inches into the abdomen. The pulmonary ligament is then divided and after that the diaphragm is split, starting at the divided costal arch and extending to the esophageal hiatus. This gives exposure of the entire esophagus below the aortic arch and the entire upper abdomen. The stomach and esophagus can then be dealt with as a unit. It is so much easier to plan the extent of the resection and to control bleeding with this exposure than it is by reaching through the diaphragm. I have used the incision through the chest, delivering the stomach into the chest and had considerable difficulty separating the bare area of the stomach from the diaphragm. Also by splitting the diaphragm it can be sutured to the gastric side of the anastomosis, thus leaving the stomach in the abdomen. I have not encountered any postoperative complications from this incision. One patient in six complained of slight tenderness of the costal arch.

(Slide.) I also had an opportunity recently to approach the left adrenal gland through a thoracico-abdominal incision. The patient was a 12-year-old girl with Cushing's syndrome. She was a little over 4 feet tall and weighed 207 lbs. The urologist who had demonstrated the adrenal tumor by x-ray was at a loss to find a suitable approach. He was afraid of damaging the tumor if he used the kidney approach and the patient was too obese for an abdominal approach. By removing the eleventh rib and splitting the diaphragm we were able to expose the retroperitoneal space directly over the tumor. The tumor lay in the perirenal fat like an egg in a nest. This indicates that a transthoracic approach to lesions of the adrenal gland or upper pole of the kidney is practical.

DR. EARLE B. KAY, Cleveland, Ohio.—In answer to Dr. Sweet's discussion:

The esophagus was removed in three of the four intrathoracic esophagoplasties performed for undilatable, benign esophageal stricture. It was left in the fourth because the condition of the patient would not permit prolonging the operative procedure. It is felt that the esophagus in such cases should be removed because of known instances of later carcinomatous proliferation.

I agree with Dr. Sweet that the antethoracic jejunodermatoesophagoplasty is not as satisfactory as an intrathoracic procedure. However, I believe that there will continue to be instances in which it would be inadvisable to perform a reconstructive intrathoracic esophagoplasty.

TECHNICAL PROBLEMS IN THE SURGICAL TREATMENT OF CARCINOMA OF THE ESOPHAGUS AND UPPER STOMACH

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DURING the past ten years the surgical treatment of cancer of the esophagus and cardia has been extended in this country to such a degree that it is fair to state that the surgical approach to this problem has been accepted in most clinics as the only form of therapy so far developed that will at the same time give a low operative mortality and the longest period of postoperative survival. The road traveled in the development of this field of surgery has not been an easy one. There has been a constant probing for methods that would lead to earlier diagnosis, repeated changes in the development of the technical problems encountered during the operative procedures, and the gradual realization of the great importance of the patient's care during the postoperative period. All of these efforts have been expended with the purpose of attaining some form of standardization in the operative treatment of this disease. On the basis of experience with over 200 cases, I would like to summarize some of our experiences with the technical problems in the operative treatment of cancer of the esophagus and upper stomach.

In trying to cope with the high incidence of cardiovascular accidents occurring postoperatively, which was the subject of a paper presented two years ago before this association, we have increased the period of preoperative preparation and made free use of the services of our medical consultant. There seems to have been some decrease in the number of this variety of postoperative complications. During the preoperative period, careful attention is now being given to the prophylaxis of pulmonary complications. These preventive measures include, first, parenteral administration of penicillin and frequently of sulfadiazine, and second, the intratracheal insufflation of penicillin by nebulization. It is our impression that there has been a marked decrease in the number of postoperative pulmonary complications since this preoperative routine was adopted. We still emphasize the importance of dental prophylaxis during the preoperative period as an additional aid in the prevention of pulmonary infections. Mechanical cleansing of the esophagus itself by frequent irrigations of the organ through a Levin tube is another important adjuvant in the prophylaxis against postoperative infections.

There is no need to emphasize the importance of careful preoperative preparation in the type of patient under discussion. Dehydration, avitaminosis, disturbances of protein metabolism, and variations in the mineral components

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of the body are frequent concomitants of the disease when the patient first presents himself. Various methods adopted to overcome these deficiencies are too well known to merit extended discussion at this time. However, it is important to emphasize that they should not be forgotten during the preoperative period.

Anesthesia.—The rapid advances in the field of anesthesiology have made continued progress in this field of surgery possible. We have gone through the various phases of anesthesia development in relationship to esophageal surgery and have finally come to the routine use of intratracheal anesthesia, which has now reached a high degree of efficiency. Anesthetists are now so well trained in the use of the intratracheal tube that there need be no hesitancy on the part of the surgeon to utilize this anesthetic modality in these frequently debilitated patients. It seems hardly necessary to emphasize that at the completion of the operation the anesthetist should routinely aspirate the bronchial tree to prevent occlusion of one or the other main bronchus postoperatively.

Midthoracic Carcinoma.—Since my original report of the high anastomosis for carcinoma of the middle third of the esophagus, enough experience has accumulated in other clinics as well as my own to justify the statement that the old Torek operation is now completely outmoded. It is now possible to bring the stomach to the apex of the chest and effect a direct anastomosis between the stump of the esophagus and the transplanted gastric organ. The important problem in this procedure is one of preservation of blood supply. It must be remembered that the only source of supply for the stump of the esophagus in this situation is through branches coming from the inferior thyroid artery. Therefore, every effort must be made to avoid trauma and extensive mobilization of the esophagus at the apex of the chest. With respect to the blood supply of the transplanted stomach, I originally suggested that the main left gastric artery should not be ligated. However, since that time experience has shown that it is feasible to ligate and divide the left main gastric artery as it arises from the coeliac axis. This maneuver alone permits extensive mobilization of the stomach. Should more mobilization be needed, the gastrocolic omentum may be divided in such a way as to preserve the gastroepiploic arch of vessels along this border of the stomach. If this is done with care, and this mobilization may be extended along the greater curvature almost two-thirds of the way to the pylorus, then the surgeon need have little fear of impairment of circulation in the proximal end when it is transplanted to the apex of the chest. We have had only one instance of necrosis of the gastric wall at the upper end of the transplanted stomach, and I am sure this was due to too extensive ablation of the blood supply along the greater curvature.

The approach that we have been using for this operation consists of a long incision in the sixth interspace with division of the sixth, fifth, fourth, seventh, and eighth ribs near the spine so as to form a T-shaped incision of the thoracic cage. The judicious use of a rib spreader gives sufficient exposure for both the thoracic and abdominal manipulations through the diaphragmatic incision.

We employ routine crushing of the phrenic nerve in order to render the left leaf of the diaphragm immobile during the operative procedure and postoperative period. The technical features of the anastomosis itself have been stressed frequently and need no extended discussion at this time. Suffice it to say that experience has shown that it is important to use interrupted sutures, preferably of the nonabsorbable variety, in order to prevent postoperative stricture at the site of the anastomosis. We have used a two-layer anastomosis of fine silk, the inner one approximating mucosa to mucosa, and the outer, muscularis of the esophagus to serosa of the stomach in the form of interrupted mattress stitches. Each suture must be placed accurately and tied without tension. To prevent disruption of this suture line, which should never be made under tension, we have telescoped the stomach over the suture line and anchored it to the esophagus above and to the mediastinal pleura on each side all the way down to the diaphragmatic opening. Before the anastomosis is completed it is advisable to aspirate the stomach completely so as to have a thoroughly flaccid organ at the end of the operation. The repair of the diaphragm around the transplanted stomach is an important item in this operation. Interrupted sutures should be placed close enough to prevent herniation of abdominal contents into the chest. Every possible opening must be obliterated and the closure should be thorough. I emphasize this point because we had the unfortunate experience of herniation of bowel into the chest in two patients, causing the death of the individual in each instance. In the first case, the ileocecal region was found herniated between rather widely placed sutures, and in the second, one of the silk sutures tore out of the diaphragm, thus creating an opening large enough to permit herniation of the transverse colon. This acted as a check-valve on the complete emptying of the stomach and the patient died of respiratory distress because of increasing distention of the stomach. The clinical picture was quite obscure and difficult to explain. The autopsy which we were fortunate to obtain told the whole story.

Carcinoma of the Lower Third of the Esophagus and Cardiac End of the Stomach.—The biopsy specimen obtained during esophagoscopy will indicate the origin of the tumor. Squamous cell tumors originate in the esophagus itself and adenocarcinomas originate in the upper end of the stomach or cardia. An adenocarcinoma may grow upward along the esophagus for quite a distance. However, I have never seen a squamous cell tumor of the esophagus grow downward along the gastric wall. Some years ago I stressed the importance of determining operability in all cases of adenocarcinoma of the cardia before subjecting the patient to a transthoracic incision. I therefore suggested a preliminary abdominal exploration through a left rectus incision. In the inoperable cases, closure of the incision terminated the operative manipulation. If the lesion was found operable, the abdominal wound was closed, the patient was turned on his side and a left transthoracic incision was then made. During the past two years I have made use of a combined abdominothoracic incision which has simplified the problem immeasurably. The development of this incision has been a natural one during the progress of this work and includes the

best features of the various incisions of this type that have been described heretofore. In the early days of this century, surgeons attempted to reach the cardiac end of the stomach without entering the chest, and all sorts of osteoplastic flap incisions were utilized by Marwedel, Von Mikulicz, Hedlbom, Ohsawa, and

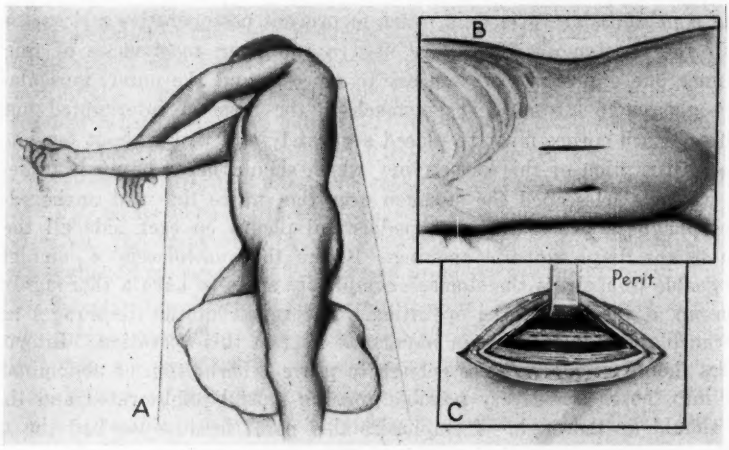

Fig. 1.—Position of patient on operating table. Beginning of incision at outer border of left rectus muscle. (Courtesy Surg., Gynec. & Obst.)

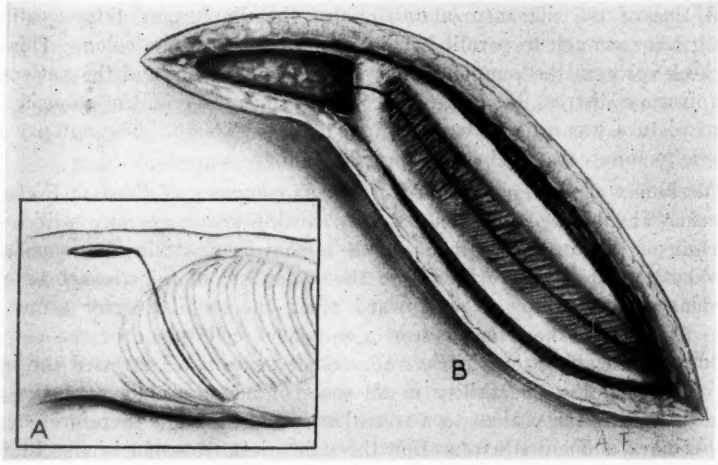

Fig. 2.—*A*, Continuation of abdominal portion of incision upward and outward into the eighth interspace. *B*, Division of the costal arch and intercostal musculature in the eighth interspace. (Courtesy Surg., Gynec. & Obst.)

others. Humphreys of New York called my attention to the many excellent features of this approach, and during the past two years I have utilized this incision almost routinely for carcinoma of the upper stomach and lower esoph-

agus. The incision affords a magnificent exposure of the upper abdomen and thoracic cavity. All operative manipulations can be done under direct vision with ease. More extensive resections can now be undertaken than was possible heretofore. It makes the operation of total gastrectomy a relatively easy procedure as compared with the usual operation done transabdominally. I have been impressed with the paucity of postoperative complications in these patients as compared with the previous group and also with the smoothness of convalescence.

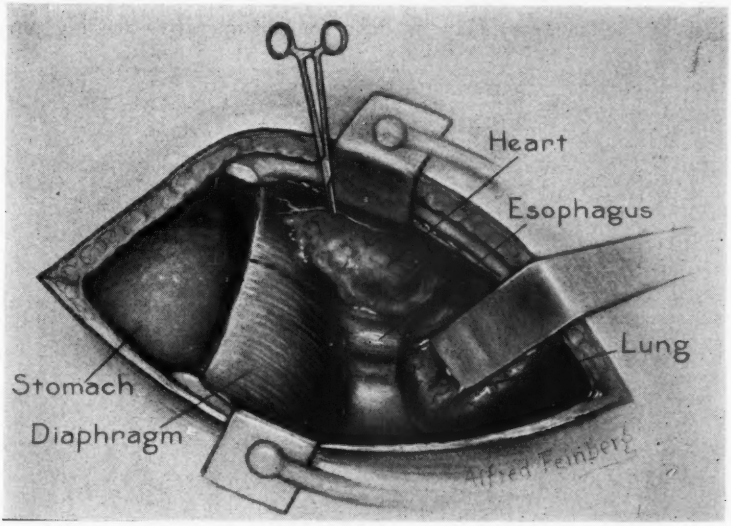

Fig. 3.—Radial incision of the diaphragm from the periphery to the esophageal opening. The phrenic nerve is pinched. (Courtesy Surg., Gynec. & Obst.)

The patient is placed almost in the exact lateral position on the edge of the operating table and an upper left rectus incision is made at the outer border of the muscle. (Fig. 1.) Exploration of the abdomen is then undertaken in order to determine operability. If an operable tumor is demonstrated, the incision is continued upward and outward in the eighth interspace. (Fig. 2.) The costal arch is divided at this point, and the incision is continued backward to the vertebral border of the scapula or further, if necessary. The chest is entered through the eighth interspace and the diaphragm is cut across in a radial direction to the esophageal hiatus. (Fig. 3.) A rib spreader is now inserted and opened widely, thus affording an extensive view of the upper half of the abdomen and lower thoracic cavity. (Fig. 4.) The esophagus, from the arch of the aorta downward, and the stomach may be mobilized with accurate division of the blood supply and complete removal of the associated lymph nodes. In squamous cell tumors of the lower esophagus it is not necessary to remove much of the upper stomach unless the paracardial lymph nodes are grossly involved. The latter is not an infrequent finding. More of the stomach

must be ablated with carcinomas of the cardia in order to effectively remove the associated lymph nodes both along the lesser curvature and the paracardial region. It has been possible through this incision to effect block dissections of the upper stomach, tail of the pancreas, spleen, and the peripancreatic lymph nodes. This would have been a hazardous and extremely difficult procedure with the old transthoracic incision. (Fig. 5.) The repair of this wound is made in layers in exactly the same manner in which it was produced. The abdominal portion of the incision may be closed quickly with buried wire sutures of stainless steel. Before complete closure of the abdominal portion of the incision, jejunostomy may be done for postoperative feeding purposes.

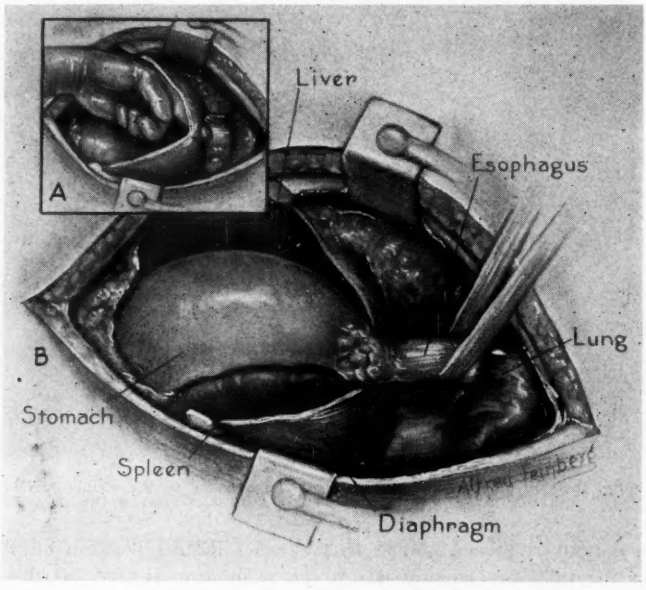

Fig. 4.—Mobilization of the lower esophagus and stomach. Lesion is located at the cardia. (Courtesy Surg., Gynec. & Obst.)

(Fig. 6.) The routine use of jejunostomy in this type of case has much to commend it. The thorax is drained by an underwater tube placed in a subjacent intercostal space. We have seen no harm done by the use of this tube and believe that it prevents accumulations of fluid in the chest which must otherwise be treated by repeated aspirations. Again I would like to stress the importance of accurate closure of the diaphragm around the transplanted stomach. This must be done in such a way as to prevent strangulation or diminution in the caliber of this organ.

Total Gastrectomy.—I would like to mention briefly the desirability of using this combined abdominothoracic incision in the performance of total gastrectomy for carcinoma of the stomach. The technical details of the operation are tremendously simplified by the use of this incision. There is one other

point that I believe deserves emphasis. In performing resections of the entire stomach and lower esophagus the surgeon is frequently confronted with the technical problem of a short jejunal loop. Sweet has attempted to overcome this defect by an exact ligation and division of the vascular arcades in the mesentery in order to obtain more mobilization. This has been a desirable advance and has simplified the problem somewhat. From the physiologic standpoint, considerable puddling takes place in the proximal or afferent loop of

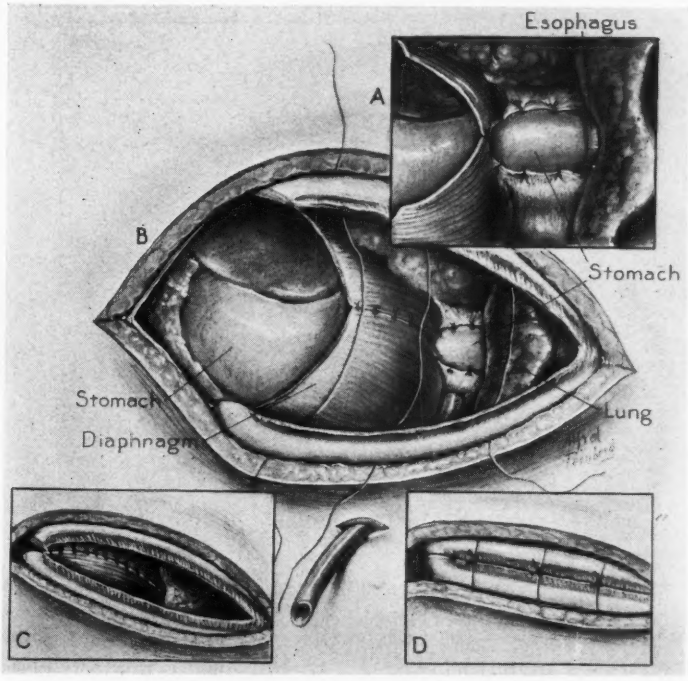

Fig. 5.—The anastomosis has been completed and the operative wound is being repaired. *A*, Fixation of mediastinal pleura and edge of diaphragm to transplanted stomach. *B*, Repair of diaphragm. *C*, Completed repair of diaphragm. *D*, Pericostal sutures inserted to close the thoracic portion of the wound. (Courtesy Surg., Gynec. & Obst.)

jejunum in spite of an enteroanastomosis, and this may produce undesirable digestive disturbances. To overcome the latter and at the same time to obtain added length to the jejunal loop, we have made use of the "Y" anastomosis of Roux during the past six months. A suitable loop of jejunum beyond the duodenojejunal junction is isolated and divided transversely. The arcades may be cut across with little fear of necrosis of the bowel ends. The distal end is inverted by two layers of silk. It is now approximated to the stump of the esophagus retrocolically, and an end-to-side anastomosis is accomplished in the usual manner. The proximal end of the divided jejunum is now anastomosed to the distal loop, end-to-side, about 8 to 10 inches below the esophago-

jejunal suture line. (Fig. 7.) The patients who have had this type of anastomosis have been singularly free of the upper abdominal digestive disturbances usually encountered in the ordinary loop anastomosis. It would seem that the proximal loop dilates and takes on the function of a reservoir for food and that puddling in the afferent loop is thereby prevented. I am suggesting this technical step as a possible improvement over the operation usually done for total gastrectomy.

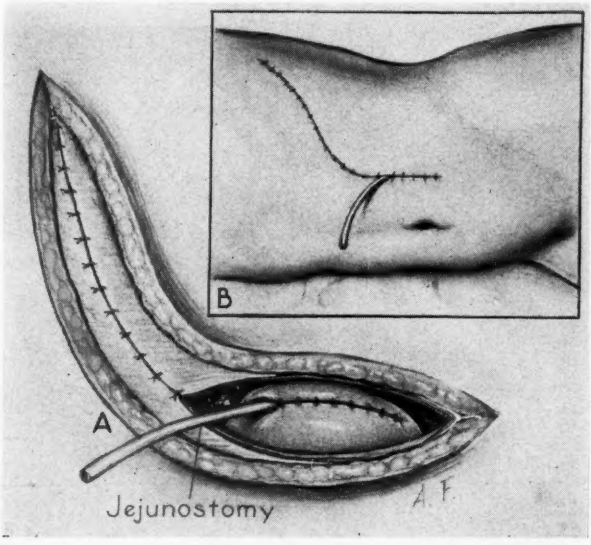

Fig. 6.—*A*, Further stage in the repair of the wound. Before closure of the abdominal portion, a jejunostomy is performed. *B*, Completed closure. (Courtesy Surg., Gynec. & Obst.)

Postoperative Care.—The postoperative care of the patients subjected to these operations is of great importance. Every patient is routinely placed in an oxygen tent immediately after operation. Thorough sedation during the first twelve to twenty-four hours is important because these patients do a lot of thrashing about during this time. Penicillin is administered parenterally. The chest is watched for accumulations of fluid and air. The most common site for trapped air is anteriorly below the clavicle on the left side. A tympanitic percussion note associated with dyspnea on the part of the patient calls for immediate aspiration. This should not be too long delayed. The clinical appraisal of the chest is probably more important than the routine bedside x-ray. Jejunostomy feedings may be started the day after operation. Of course, it is unnecessary to emphasize the importance of transfusions both during the operation and postoperative period. Swallowing is interdicted until the fourth day, when sips of water may be permitted. The quantity is rapidly increased until the seventh or eighth day, when junkets, custards, and gelatins are added

to the diet. Thereafter the food intake may be stepped up so that the patient is able to enjoy practically a full diet by the end of the third week.

It has been astonishing to see these frequently debilitated patients go through these extensive resections with the postoperative chart simulating that of an interval appendectomy. The rapidly diminishing mortality rate of these operations has emphasized the importance of a combination of features.

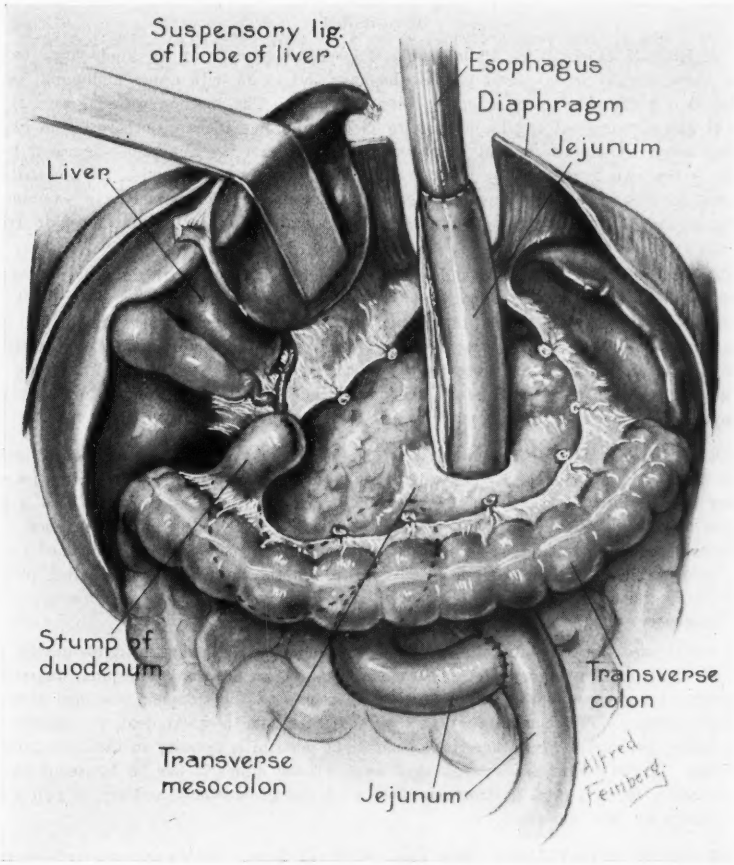

Fig. 7.—Diagrammatic representation of the completed operation of total gastrectomy performed through a combined abdominothoracic incision and showing the Y-anastomosis of the jejunum. About 18 inches beyond the duodenojejunal junction the jejunum and its mesentery has been divided. The distal end is brought through an opening in the mesocolon and sewed to the opened end of the esophageal stump in the usual manner. The proximal end of jejunum is implanted end-to-side into the distal portion below the mesocolon.

These may be enumerated as (1) careful preoperative preparation, (2) expertly administered anesthesia, (3) atraumatic surgery with minimal loss of blood, free exposure, and accurate suture methods, and (4) careful attention to the many details of the postoperative care. The increasing number of long sur-

vivals following these operations is indicative of the fact that we are becoming aware of the necessity for a thorough cancer operation which includes the wide removal of the cancer-bearing focus and all of its associated lymphatic tributaries. Until the exact cause of this disease becomes evident, our only hope in attaining an increasing percentage of cures is that patients will be referred at an earlier date for surgical treatment than has been the case heretofore.

DISCUSSION

DR. RUBIN M. LEWIS, Philadelphia, Pa.—Developments of all kinds have to come in their chronological order: most people who have had to do with upper abdominal surgery have found it preferable to use a one-incision approach. The incision we suggested is, perhaps, not entirely original for I am sure we picked up some ideas elsewhere. The impressing thing about the approach, and in contradistinction from the approach suggested by Dr. Garlock, is that we have recently become more and more impressed with the necessity for transverse incision, especially through the rectus muscle. I had occasion to examine one of these wounds about thirty days postoperatively, and found an excellent repair from a transverse rectus incision.

The danger of herniation through a transverse incision is a little less than through a vertical incision. The exposure that one gains by coming down either through the bed between the eighth and ninth ribs, or taking out the ninth rib, as we suggested, and going transversely across the rectus gives a much better exposure to the abdominal cavity and certainly gives an excellent exposure to the lower thorax, and perhaps a little more room than one can get with a vertical rectus incision; if the room is not adequate for a total gastrectomy, the right rectus incision may be used with this incisional approach.

DR. G. H. HUMPHREYS, New York, N. Y.—We have used the combined incision, such as Dr. Lewis described, starting with an obliquely transverse incision across the upper abdomen to determine operability. It is good for exploration, and through it a gastrostomy can be done if the lesion is inoperable. Then, by placing the patient in such a way that the table can be rotated, the patient is rotated and the incision carried upward into the chest, either excising the eighth rib or going through the eighth interspace and, if necessary, dividing the eighth and seventh ribs if the lesion runs as high as the pulmonary hilus. It has been very satisfactory.

I would also like to make one comment, on something Dr. Kay said about the desirability of doing an esophagogastric anastomosis rather than an esophagojejunal anastomosis. The results of our cases where only a very small stump of the stomach remained have been very disappointing. It seems to us that these patients have a great deal of difficulty with pyloric spasm, perhaps because there is not sufficient peristaltic activity in the remaining gastric stump. If the lesion is so large that most of the stomach has to be removed, it is probably better to do a total gastrectomy than a partial gastrectomy and try to pull a small gastric stump up into the chest.

DR. LOUIS R. DAVIDSON, New York, N. Y.—I should like to add my testimony relative to the advantages which are obtained with the use of the combined thoracoabdominal incision. Surgeons in New York have been stimulated by the work of both Dr. Garlock and Dr. Humphreys. In many instances the thoracic approach becomes confounding and the surgeon wonders whether he is doing the proper thing for the patient by merely opening the chest, incising the diaphragm, finding much to his consternation that he has an inoperable case, and of necessity backing out.

I was fortunate in witnessing Dr. Humphreys use his combined incision, and feel that he did not sufficiently emphasize the fact that he makes his abdominal incision first, and then after ascertaining that the lesion is operable, he continues in the fashion Dr. Garlock described.

I should like to add one point in regard to the incision. It is parallel with the eighth rib, as you saw, and runs down to the abdomen in the same direction. The exposure is magnificent.

In a case which was operated upon by me six weeks ago, we had adequate exposure, removing a little more than half the stomach, about three inches of the esophagus, the pancreas up to the origin of the coeliac axis, the spleen, and part of the left adrenal. The patient is about, walking. He had a slight empyema. This operation could never have been completed if it had not been for the thoracoabdominal incision, which not only permitted us to ascertain whether this case was operable but also gave very adequate exposure.

DR. JOHN H. GARLOCK, New York, N. Y.—There is very little to add. The smoothness of the postoperative course in these patients, and the relative absence of pain, is quite different for the convalescence of the patients who have had rib resections and rib splitting. I think the fact that we are not removing any ribs may be the explanation of that.

I agree with Dr. Humphreys that when you are left with a small stump of stomach it is much easier to take out the remainder than to anastomose a short prepyloric stump.

The pyloric spasm the patients have is due to the fact that one cuts both vagus nerves, and it is usually corrected by belladonna or atropine. This undesirable symptom may impede the patient's progress postoperatively, but usually it disappears spontaneously after a few months.

SUPRADIAPHRAGMATIC SECTION OF THE VAGUS NERVES TO THE STOMACH IN GASTROJEJUNAL ULCER

LESTER R. DRAGSTEDT, PH.D., M.D. (BY INVITATION), JAMES S. CLARKE, M.D., PAUL V. HARPER, JR., M.D., EDWARD R. WOODWARD, M.D., AND E. BRUCE TOVEE, M.D.
CHICAGO, ILL.

PREVIOUS reports from this clinic[1] have dealt with the technique of both supra- and subdiaphragmatic section of the vagus nerves to the stomach and with the results of this procedure on gastric secretion and motility in patients with peptic ulcer. The prompt relief of ulcer distress that invariably occurs and the objective evidence of the healing of the lesions have been described. Further work on these problems has been conducted in both the laboratory and the hospital, and it is the purpose of this communication to present the findings, some of which confirm and extend observations previously recorded. In addition, the results of gastric vagotomy in a series of intractable gastrojejunal ulcers will be described.

The theoretical basis for section of the vagus nerves to the stomach in the treatment of peptic ulcer is relatively simple and may be summarized in part as follows:

1. Present medical and surgical procedures that are effective in the treatment of peptic ulcer are designed to neutralize the acid gastric juice or to decrease its production. The first is usually attempted by frequent feeding and the administration of alkalies, and the second by subtotal gastrectomy or x-ray therapy to the stomach. To the extent that these measures accomplish their purpose, favorable results, in general, have been secured.

2. When an excessive continuous secretion of gastric juice is maintained in experimental animals, peptic ulcers appear in the stomach or duodenum, progress, and cause hemorrhage or perforation. This experiment of crucial importance was made by Wangensteen and his associates.[2] Excessive and long-continued gastric secretion was produced by implanting pellets of histamine and beeswax into the subcutaneous tissues.

3. An excessive continuous secretion of gastric juice occurs in most patients with peptic ulcer. The work of the older gastroenterologists demonstrated that patients with ulcers, on the whole, secrete a little more gastric juice in response to the stimulus of food, alcohol, or histamine than do normal individuals. The difference is, however, not very great, and is not sufficiently uniform to have much diagnostic value. It is in the activity of the empty stomach that the more striking contrast is seen. This is best determined at night when the patient is shielded from the sight and odor of food, and the stomach has been

From the Department of Surgery, University of Chicago.

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carefully emptied and lavaged. A Levine tube is introduced through the nose into the stomach and constant suction maintained for twelve hours until the following morning. Under these conditions, an average of 250 to 400 c.c. of fluid is obtained from the stomach of normal adults and of patients with gall stones, regional enteritis, and miscellaneous diseases other than peptic ulcer. The free acidity of this aspirate ranges between 0 and 20 clinical units, indicating that the output of the parietal cells is small and that considerable dilution and buffering have occurred. Patients with duodenal ulcer, on the other hand, have uniformly been found to yield under identical conditions a night secretion of 600 to 2,500 c.c. with free acidity of 40 to 110 clinical units. If this is calculated in terms of hydrochloric acid content, it is apparent that the ulcer patient secretes from two to ten times as much acid as does the normal individual when there is no obvious stimulant to the gastric glands.

4. Section of the vagus nerves to the stomach reduces the secretion of gastric juice in normal animals and in patients with peptic ulcer to an even greater degree. The classic researches of Pavlov first demonstrated that the secretion of gastric juice which occurs in dogs in response to the sight, odor, or taste of food is abolished by cutting the vagus nerves. Precise data concerning the relative proportion of the total gastric secretion that is due to these reflexes over the vagus nerves has been difficult to obtain. It has long been known that secretion persists after complete vagotomy when food is present in the stomach or upper intestine. This is mediated by humoral, and possibly other factors, but its volume is uncertain. Orbeli[3] prepared an isolated Pavlov pouch in a dog and collected 23.8 c.c. of gastric juice in a seven-hour period following the ingestion of 100 Gm. of meat. The vagus nerves to the pouch were then divided, and when the experiment was repeated, the secretion fell to 4.3 c.c., or approximately one-fifth of the previous figure. Apparently, no attempt was made to collect the twenty-four hour secretion from the pouch before and after vagotomy. We are now studying this problem in our laboratory, and a detailed report will be made elsewhere. The entire stomach of the dog is isolated by transection at the cardia and pylorus.[4] The ends are closed, and a suitable cannula is inserted to collect the gastric juice. Care is taken not to interfere with the blood and vagus nerve supply to the isolated stomach. Continuity of the alimentary tract is re-established by anastomosing the lower end of the esophagus to the duodenum or to the side of the jejunum. With such a preparation, it is possible to collect all of the gastric secretion for periods of several weeks to a month or longer. One such animal secreted an average of 1,100 c.c. of gastric juice per twenty-four hours for a two-week period, with a free acidity of 116 clinical units. This fell to an average of 410 c.c. with a free acidity of 30 clinical units after division of the vagus nerves above the diaphragm. A second animal secreted an average of 500 to 800 c.c. with a free acidity of 33 to 90 clinical units before vagotomy, and this was reduced to 40 to 100 c.c. with a free acidity of 0 to 12 clinical units after the vagus section.

It is clear that in such a preparation neurogenic factors play a much greater role than humoral or other influences in determining the total volume of gastric juice produced in twenty-four hours and especially the output of acid. In the first case, the acid secreted was reduced by the vagotomy to one-tenth

of the original amount, and in the second, to about one-sixtieth of that originally produced.

It is probable that a similar or even greater reduction in gastric secretion is produced by vagotomy in patients with peptic ulcer. It has been a standard procedure in this clinic to determine the night secretion in ulcer patients before and after section of the vagus nerves to the stomach. To date, such data have been obtained on 105 patients. The acid output of the stomach has been reduced by the operation to one seventh of the preoperative average and falls within the range of that found in normal individuals. This proves that the increased continuous secretion in ulcer is neurogenic in origin and is dependent upon a secretory hypertonus in the vagus nerves. Observations on the effect of vagotomy on the response of the gastric glands to the stimulus of food, histamine, and caffeine have also been made, largely by Mr. Harry Oberhelman, Jr. The concentration of acid resulting from histamine and caffeine has been unchanged, but the volume of secretion seems definitely reduced. It is exceedingly difficult to subject the gastric glands to the normal stimulus of food and then measure the volume of gastric juice produced. Data to date have been limited to the measurement of the concentration of free acid in fractional samples of gastric content removed at varying intervals after the meal. These will be reported elsewhere. They show that, whereas the well-known curve of increasing acidity of the gastric content was the rule before operation, after the vagotomy the gastric secretion was so reduced that free acid was not found, although fractional samples were studied for as long as five hours after ingestion of the meal.

The relief of ulcer distress following vagotomy has been so uniform, prompt, and complete as to suggest that the stomach has become anesthetic through removal of its sensory nerve supply. This is, however, not the case. Most of the patients subjected to subdiaphragmatic vagotomy have been given a spinal anesthetic. Under these conditions, mobilizing, pinching, tying, and cutting the vagus nerves have caused no sensation. A more crucial experiment was performed on two patients with duodenal ulcer who were experiencing severe distress when they entered the hospital. This distress was relieved temporarily by emptying the stomach but recurred in severe form when 200 c.c. of 0.5 per cent hydrochloric acid solution were instilled into the stomach (Palmer's acid test). Following vagotomy, both patients experienced immediate and complete relief. On the third day, while the patient's attention was diverted, the Wangensteen suction apparatus was disconnected and 200 c.c. of 0.5 per cent hydrochloric acid, warmed to body temperature, were injected slowly through the Levine tube into the stomach. Within ten minutes, severe epigastric pain similar in character to the previous distress appeared, and this was promptly relieved by withdrawing the injected acid. These findings suggest that the relief of pain produced by vagotomy is due chiefly to the marked reduction in the acidity of the gastric content. Doubtless, the reduction in the tonus and motility of the stomach also plays an important role, but the relief is certainly not due to anesthesia.

That section of the vagus nerves to the stomach causes the ulcers to heal is indicated by the persistent relief of symptoms in spite of cessation of all

medication and dietary restrictions, gain in weight, and evidence of healing as determined by fluoroscopic study, i.e., disappearance of craters and lessening of deformities. In two cases of long-standing large gastric ulcers, these criteria have been supplemented by direct visualization with the gastroscope. Following vagotomy, the ulcers healed, and the mucosa in the ulcer area became nearly normal in appearance. Gastrojejunal ulcers are notoriously difficult to treat, spontaneous healing rarely occurs, and consequently, the response of these ulcers to vagus section is of more than usual interest. The following abbreviated protocols contain most of the relevant data in ten patients with gastrojejunal ulcers who have been treated to date in this clinic by gastric vagotomy.

I. C., a male aged 27, was first seen Jan. 12, 1943, complaining of epigastric pain coming on after meals and relieved by taking food or alkali. In 1936, a gastroenterostomy was performed for ulcer with obstruction. The distress was relieved temporarily but recurred in a few months. The patient frequently had diarrhea during exacerbations and occasionally had tarry stools. X-ray examination revealed a large crater in the jejunum near the gastroenterostomy with marked deformity and almost complete obstruction of the duodenal bulb. On Feb. 3, 1943, a subtotal gastrectomy was performed. The patient was relieved of symptoms for five months and gained much weight. He then began having severe epigastric pain and tarry stools. X-ray revealed a stoma ulcer. The patient was readmitted June 30, 1944, and a transthoracic vagotomy was performed. Following the vagotomy, the night pain disappeared. Cramplike epigastric pain appearing during the course of eating persisted, however, but vanished when the patient adopted the practice of eating slowly and small amounts at more frequent intervals. X-ray examination revealed complete healing of the ulcer. This probably represents a favorable response to vagotomy so far as healing of the ulcer is concerned, but persistence of symptoms due to the subtotal gastrectomy.

C. B., a male aged 42, was first admitted to this clinic Nov. 7, 1944. He complained of epigastric distress occurring several hours after meals and at night ever since he was 16 years old. The ingestion of food or milk always relieved the pain. In 1928, a posterior gastroenterostomy was performed for duodenal ulcer. Following this operation, his abdominal pain persisted and he developed diarrhea. He was operated upon again in 1930, at which time a gastrojejunocolic fistula was found. This was closed, and the gastroenterostomy taken down. The epigastric pain persisted, and in 1938 a subtotal gastrectomy was performed. This provided temporary relief, but early in 1944 symptoms recurred, and x-ray examination revealed a gastrojejunal ulcer. Medical management provided only partial and temporary relief, and he began to vomit. X-ray examination in this clinic, November 14, revealed a large jejunal ulcer. On November 18, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was uneventful. On Feb. 28, 1945, x-ray examination revealed a decrease in the size of the ulcer crater. The epigastric distress improved, and he began to eat very well, but was severely injured in an automobile accident in 1945. He was readmitted April 19, 1945, because of epigastric distress. The pain was not like the previous ulcer distress, but more a feeling of distention, coming on immediately after meals and not relieved by alkali, with no nausea or vomiting, but occasional sudden feelings of weakness. He left the hospital suddenly April 23, 1945, before studies were completed. Dr. Warren Cole has subsequently informed us that he performed a total gastrectomy on this patient because of obstructive symptoms. At this time, examination of the resected specimen showed that the ulcer had healed.

M. B., a male aged 56, was first seen in this clinic on June 20, 1942. Twelve years before, he began to have epigastric distress and consulted a physician, who made a diagnosis of duodenal ulcer. He was placed on medical management and did fairly well until ten days before entering the hospital, when he developed severe epigastric pain and had a massive hemorrhage. Subsequently, x-ray studies showed a duodenal ulcer with a large

crater. X-ray therapy to the stomach was given and considerable improvement resulted. In November, 1942, he developed obstructive symptoms, and a posterior gastroenterostomy was performed. He was well for one year following this operation; then symptoms recurred, and x-ray examination revealed a gastrojejunal ulcer. Medical management failed to give relief. On Nov. 8, 1944, the gastroenterostomy was taken down, and on November 24, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was uneventful. When last seen in July, 1946, he reported that he had experienced no ulcer distress since the operation, had gained 40 lbs. in weight, and was eating a liberal diet and taking no medication. This represents a successful result to date, but is complicated by the taking down of the gastroenterostomy.

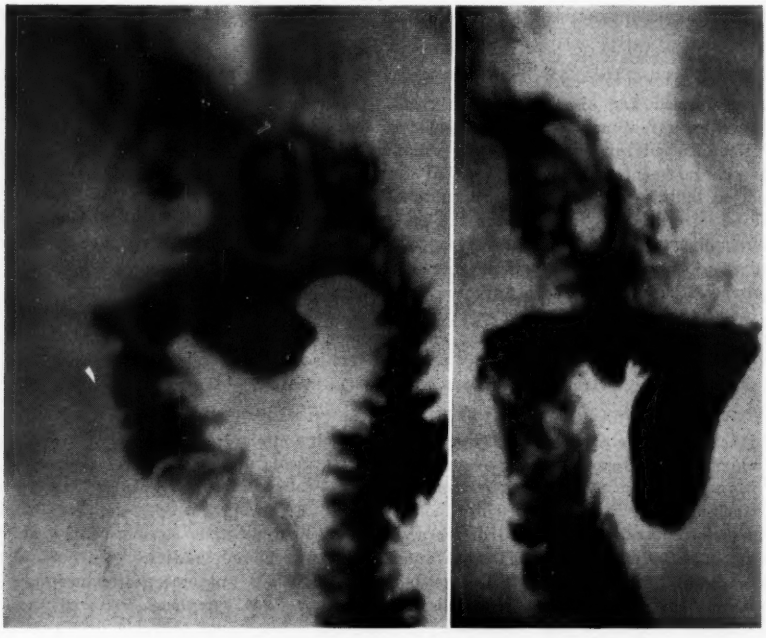

Fig. 1. Fig. 2.

Fig. 1.—Large gastrojejunal ulcer crater in patient G. P. appearing eleven months after subtotal gastrectomy.

Fig. 2.—Same patient as in Fig. 1, showing decrease in size of ulcer crater forty-nine days after section of vagus nerves to the stomach.

J. W., a male aged 60, was first seen in this clinic Sept. 15, 1942. He gave a history of epigastric distress for the previous twenty-five years. In 1936, a gastroenterostomy was performed. Epigastric distress recurred in 1940, and x-ray examination revealed a gastroenterostomy, and just above it, a large gastric ulcer. The ulcer was visualized with the gastroscope. X-ray therapy to the stomach was given, and on December 22, the ulcer disappeared and was not demonstrated on either x-ray or gastroscope examination. In August, 1943, symptoms recurred, and the ulcer reappeared at x-ray and gastroscopy. Strict management was instituted with some decrease in the size of the ulcer, but this increased again in the latter part of 1944. On Nov. 27, 1944, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was uneventful, but was complicated by persistent pain in the region of the incision. When last seen in September, 1946, he still complained of pain in the region of the chest incision. His ulcer distress was relieved from

the time of the operation, and no dietary restrictions were followed. No medication was taken. This has been a successful result to date except for the persistence of pain in the chest.

A. W., a male aged 47, was first admitted to the clinic on Nov. 24, 1944. He complained of epigastric distress which had been present for the previous fifteen years. A diagnosis of duodenal ulcer had been made. Diet and powders controlled the pain fairly well during this period. Symptoms recurred, however, and two years before entering the hospital a gastroenterostomy was performed elsewhere. Following this operation he was well until four hours before admission, when he developed pain in his left side and began

Fig. 3.—Same patient as in Fig. 1 showing complete disappearance of ulcer crater seventy-four days after vagotomy.

to vomit blood. The gastric hemorrhage was controlled, and on November 29, x-ray examination revealed a well-functioning gastroenterostomy with a gastrojejunal ulcer with a crater. On December 11, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery from the operation was uneventful except for a slight pleural effusion on the left side which did not require tapping. Ulcer symptoms were entirely relieved, and x-ray examination on Jan. 9, 1945, failed to reveal the crater at the anastomosis. When last seen in February, 1945, he was free from distress, eating a regular diet, and taking no powders. The immediate response of this patient to vagotomy was very satisfactory, but the present status is unknown.

G. P., a male aged 48, was admitted to this clinic on March 2, 1944. Twenty years before, he first experienced abdominal pain accompanied by nausea and vomiting. A diagnosis of duodenal ulcer was made. Medical treatment proved unsuccessful, and in 1925 a gastroenterostomy was performed. This gave only temporary relief, and in 1939 x-ray studies revealed a gastrojejunal ulcer. He continued to have epigastric distress with occasional bouts of vomiting during the ensuing five years. When he entered the clinic, x-ray exam-

ination of the stomach March 8, 1944, revealed a large gastrojejunal ulcer. On April 3, the gastroenterostomy was taken down, and a subtotal gastrectomy was performed. Symptoms were entirely relieved until February, 1945, when the abdominal pain returned. X-ray examination on Feb. 14, revealed the reappearance of a very large gastrojejunal ulcer (Fig. 1). On March 12, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Immediate relief followed this operation, and he was able to eat a liberal diet without medication. Subsequent x-ray studies on April 30 (Fig. 2), showed decrease in the size of the crater, and on May 25 (Fig. 3), complete disappearance of the crater. When last seen in October, 1946, he was entirely well, eating an unrestricted diet without distress and with no medication. This represents a dramatically favorable response of an exceptionally large jejunal ulcer to vagotomy.

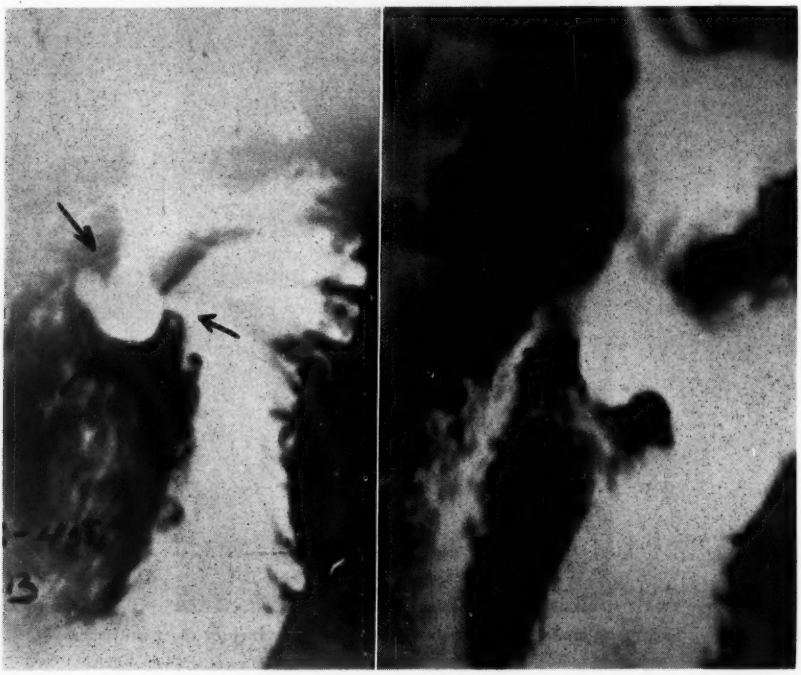

Fig. 4. Fig. 5.

Fig. 4.—Large gastrojejunal ulcer crater in patient M. S. appearing six months after subtotal gastrectomy.

Fig. 5.—Same patient as in Fig. 4, showing decrease in size of ulcer crater twenty-four days after vagotomy.

M. S., a male aged 36, was first seen on Aug. 29, 1938. For the past two months he had been complaining of typical ulcer distress and x-ray examination revealed a duodenal ulcer with a crater. Symptoms were controlled for a time on medical management, but recurred in 1943, at which time a subtotal gastrectomy was performed. At operation, a chronic duodenal ulcer penetrating into the pancreas was found. Six months after the operation a recurrence of symptoms developed, and a gastrojejunal ulcer was demonstrated at x-ray. X-ray therapy to the stomach was then given with relief of symptoms, and there was apparent disappearance of the ulcer. The ulcer recurred in six months (Fig. 4) and pain became severe. On March 23, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was uneventful, and the patient was entirely relieved

of ulcer distress. X-ray examination on April 16, revealed definite decrease in the size of the ulcer crater (Fig. 5), and on May 9, complete disappearance of the crater (Fig. 6). When last seen in August, 1946, he was working regularly, eating an unrestricted diet without medication, and stated he had experienced no ulcer distress since the operation. This represents a strikingly favorable response of a large jejunal ulcer to vagotomy.

J. V., a male aged 50, was admitted Jan. 11, 1946, complaining of epigastric distress, coming on one to two hours after meals, of twenty-four years' duration. In 1923, the patient had a partial gastrectomy. Following this he was free of symptoms until four years ago when the ulcer distress recurred. The patient had tarry stools with each attack. For one year, pain had been severe and accompanied by vomiting. X-ray examination showed a large gastrojejunal ulcer (Fig. 7). On January 21, transthoracic vagotomy was performed by Dr. Hilger Jenkins. The postoperative course was uneventful. X-ray examination on April 26 showed complete healing of the stoma ulcer (Fig. 8). When last seen in October, 1946, he had gained 18 lb., was eating an unrestricted diet, and had no epigastric distress. No medication was taken at any time following operation.

Fig. 6.—Same patient as in Fig. 4, showing complete disappearance of ulcer crater forty-seven days after vagotomy.

A. W., a male aged 59, was first seen on Jan. 19, 1946 with the complaint of burning epigastric pain of one and one-half years' duration. The distress came on about two hours after meals and was usually relieved for an hour or two by food, milk and cream, or alkali. He got along fairly well until three years ago, when intensive medical treatment for one year failed and a gastroenterostomy was done. The patient was symptom-free for about six months. The pain then recurred, has been more severe, and food and alkali have had less palliative effect. There was no history of perforation, stenosis, or hemorrhage. X-ray examination on Jan. 23, 1946, revealed a patent gastroenterostomy, at least one clean-cut jejunal ulcer, and probably a second shallow ulcer. Transthoracic vagotomy was performed February 11, and the postoperative course was entirely uneventful. When last seen in July, 1946, he had gained 10 lb., was working daily, and had no distress although he was eating an unrestricted diet and taking no medication.

M. S., a female aged 41, was admitted May 14, 1946, complaining of peptic ulcer of eighteen years' duration. In 1932, this patient had a gastroenterostomy performed for perforating duodenal ulcer. She had had symptoms for seven years previously. She was entirely well for five or six years after this, but then began to notice periodic gnawing epigastric pain coming on one and one-half to two hours after meals and relieved by milk. Each spring and occasionally in the fall, she would have an episode lasting five to eight days of vomiting, severe headache, and tarry stools. The patient was seen here in the medical clinic Oct. 19, 1943, at which time x-ray disclosed a moderate stenosis of the gastroenterostomy stoma with a definite crater. On medical treatment, including x-ray therapy, the crater disappeared and the patient felt well until eight months before admission. She then began having epigastric distress, and six weeks before admission had a massive hemorrhage.

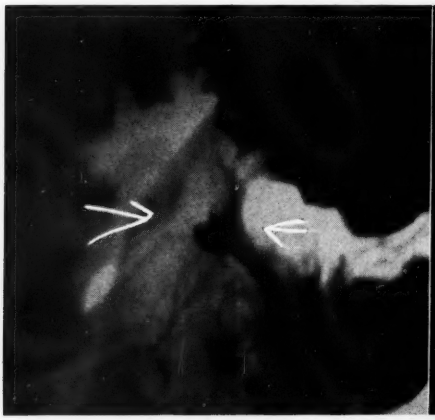

Fig. 7.

Fig. 8.

Fig. 7.—Gastrojejunal ulcer crater in patient J. V. appearing four years after partial gastrectomy.

Fig. 8.—Same patient as in Fig. 7, showing complete disappearance of ulcer crater ninety-five days after vagotomy.

The patient's father has had a subtotal gastrectomy for peptic ulcer, and three brothers all have peptic ulcer. The patient had chorea at the age of 9, and now has evidence of mitral insufficiency and stenosis without history of heart failure. Preoperative x-rays demonstrated a stomal ulcer in October, 1945, with considerable narrowing. In April, 1946, the crater could not be visualized, but the stoma was almost completely obstructed. The transthoracic vagotomy was performed on May 17, 1946. Postoperative recovery was uneventful except for three days of unexplained lethargy and semistupor. Patient was discharged on the tenth postoperative day. One month after operation, the patient had no ulcer pain or distress, no diarrhea, no dietary restrictions, and no medication. She still has occasional pain in her incision. X-rays show the gastroenterostomy to be functioning normally without evidence of crater.

DISCUSSION

The dramatic healing of large gastrojejunal ulcers as a direct result of section of the vagus nerve supply to the stomach is perhaps the best evidence of the therapeutic effectiveness of this procedure. Spontaneous healing of these lesions rarely occurs, and they are often refractory to the most rigid dietary and medical management. In addition to pain and distress resulting from the presence of the ulcer itself, many of these patients suffer from obstructive symptoms due to deformity of the jejunum and secondary inflammatory reaction of the neighboring tissues. It is important to recognize this complication

since, of course, the obstruction is often not relieved by the vagotomy even though the ulcer heals and gastric retention may become even more marked as a result of the decrease in tonus and motility of the stomach. Our second case falls in this category, and the patient was dissatisfied with the operation because of the persistence of obstructive symptoms. Recurrence of ulcer following subtotal gastrectomy is occasionally complicated by symptoms arising as a result of the absence of a large part of the stomach or from distention of the portion of jejunum employed for the anastomosis. These factors are probably illustrated by our first case. This patient was a sailor and was accustomed to bolting his food. Vagotomy relieved his ulcer pain and brought about disappearance of his ulcer crater, but he continued to experience epigastric distention and cramps during meals. This was relieved when he adopted the practice of eating small amounts of food at more frequent intervals.

Complete division of the vagus nerve supply to the stomach may be accomplished by the thoracic or abdominal operation. The better exposure of the lower esophagus secured when the left chest is opened makes it somewhat easier to isolate the vagi and to make certain all gastric fibers are divided. The use of this approach in gastrojejunal ulcers following subtotal gastrectomy or other multiple abdominal operations has the additional advantage of avoiding the sometimes troublesome adhesions commonly present. An undeniable disadvantage results from inability to examine the lesion directly and to deal with obstruction, should it be found. In two recent gastrojejunal ulcers treated by us and not included in this report, vagotomy was accomplished easily by the abdominal operation. Further experience is necessary before a final decision regarding the best approach for vagus section in these lesions can be reached. Individual factors such as body contour and amount of fat also bear on the problem.

The finding that gastrojejunal ulcers heal following vagotomy is of interest in connection with the employment of gastroenterostomy in ulcer patients. In many clinics, this operation has been entirely abandoned or used only in old people with high-grade cicatricial pyloric stenosis and low acid concentration in the gastric secretion. For the most part, the high incidence of gastrojejunal ulcer has been responsible for this disfavor. To date, we have employed transabdominal vagotomy plus gastroenterostomy in fifty patients with duodenal ulcer. Many of these had pyloric obstruction as indicated by symptoms and fluoroscopic examination. The results so far have been excellent, and no secondary stomal ulcers have developed. While the period of observation is still too short for this data to be of significance, it seems highly probable that since vagotomy permits an already established stomal ulcer to heal, a new lesion of this type should not develop in a normal mucosa.

CONCLUSIONS

1. Ten patients with gastrojejunal ulcers following gastroenterostomy or partial gastrectomy have been treated by supradiaphragmatic section of the vagus nerves to the stomach. Healing of these lesions has been secured, as evidenced by relief of distress and by fluoroscopic demonstration of disappearance of large ulcer craters.

2. The relief of ulcer distress uniformly produced by vagotomy is not due to anesthesia of the stomach. This is indicated by the immediate reappearance of typical pain when acid is instilled into the stomach during the first few days after operation.

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DISCUSSION

DR. D. T. SMITH, Durham, N. C.—One of our surgeons at Duke, Dr. Keith Grimson, has performed this operation of Dr. Dragstedt's on about thirty patients in the last two years. In each case the approach was the supradiaphragmatic.

We have a whole team working on the problem, which requires the cooperation of roentgenologist, gastroenterologist, and neurologist. In all cases the pain has been relieved immediately and there has been no recurrence of bleeding in any of these patients. All patients have good appetite and are free of pain, but many overindulge in food. Some of them have developed large dilated stomachs and they have learned to massage manually to force the excess food through the pylorus.

DR. FRANK B. BERRY, New York, N. Y.—I should like to ask Dr. Dragstedt one question. That is the question of pylorospasm, as an after-effect of vagectomy.

Some of the neurosurgeons have told me that the operation is impracticable because of this complication, and pyloroplasty will necessarily follow. Inasmuch as Dr. Dragstedt has been performing this operation for three years, I would like to know his late results.

DR. LESTER R. DRAGSTEDT, Chicago, Ill.—With regard to the question of pyloric spasm following vagus section, I think it is true that a long-continued increase in the tonus of the pylorus is produced by vagotomy, but if there is not cicatricial obstruction of the pylorus, it does not seem to cause subsequent difficulty. In the majority of our patients ulcers were present in the duodenum. There was considerable deformity of the bulb and spasm, but following transthoracic vagus section, these patients, with the exception of two, have been relieved and eat large amounts of food. They have gained a great deal of weight and have had no subsequent gastric distress.

One of the patients went out on a picnic, ate a great amount of food and watermelon three months after the operation, and came to the hospital with an acute dilatation of the stomach. We decompressed him, operated upon him, and found a fibrous stenosis at the pylorus. The lumen had been decreased. We did a gastroenterostomy and subsequently he has remained well.

One problem for which I have no adequate answer is the degree of pyloric obstruction that will require gastroenterostomy in addition to the vagus section. It is difficult to determine. At the present time I follow this rule. If the patient gives a clinical story of retention with repeated vomiting, a gastroenterostomy is performed.

AN ANNOUNCEMENT OF OPPORTUNITIES FOR THORACIC SURGEONS IN VETERANS' ADMINISTRATION HOSPITALS

BRIAN BLADES, M.D.
WASHINGTON, D. C.

GENERAL HAWLEY asked me to appear before this Association to emphasize the need for thoracic surgeons in Veterans' Administration Hospitals.

In order to attract desirable surgeons, three factors have been considered: (1) provisions for large enough surgical services to furnish an adequate volume of clinical material and opportunities for clinical research; (2) adequate pay; and (3) freedom from administrative duties which will interfere with professional work.

It is possible to state without qualification that opportunities for clinical research in thoracic surgery are available in many veterans' hospitals, particularly in the field of tuberculosis.

Financial remuneration is based on the surgeon's previous training and ability. Men certified by their respective specialty boards receive 25 per cent more base pay. This is, of course, an obvious attempt to attract well-trained surgeons.

The Department of Medicine and Surgery in the Veterans Administration is no longer under Civil Service. Every attempt is being made to eliminate nonprofessional administrative duties which would obstruct a pleasant and useful professional career.

There has been the inevitable confusion during the period of reorganization. Many applications for positions in Veterans Administration hospitals have not been acknowledged promptly. The plan of organization is not generally understood and in some instances applicants have obtained conflicting opinions. For this reason I should like to describe very briefly the present organization.

In the Department of Medicine and Surgery headed by the Chief Medical Director, General Hawley, all of the principal medical and surgical specialties are represented at the central office by directors in the particular field. Dr. Elliott C. Cutler is the Chief of Professional Services.

One of the first objectives in the development of veterans hospitals is to decentralize the organization. Accordingly, branch directors in the various specialties have been appointed for the thirteen branch areas into which the country is divided (Figs. 1 and 2). The appointment of the branch director in thoracic surgery in Area No. 11 has not been made but will be announced soon.

In cities where the geographic location of medical schools make it feasible to have the school or schools assume the responsibility of staffing hospitals, the Dean's Committee Plan is in operation if the school is willing to cooperate.

Read at the Twenty-sixth Annual Meeting of The American Association for Thoracic Surgery, Detroit, Mich., May 29, 30, and 31, 1946.

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Fig. 1.—Map demonstrating the thirteen branch areas in the Veterans' Administration Organization.

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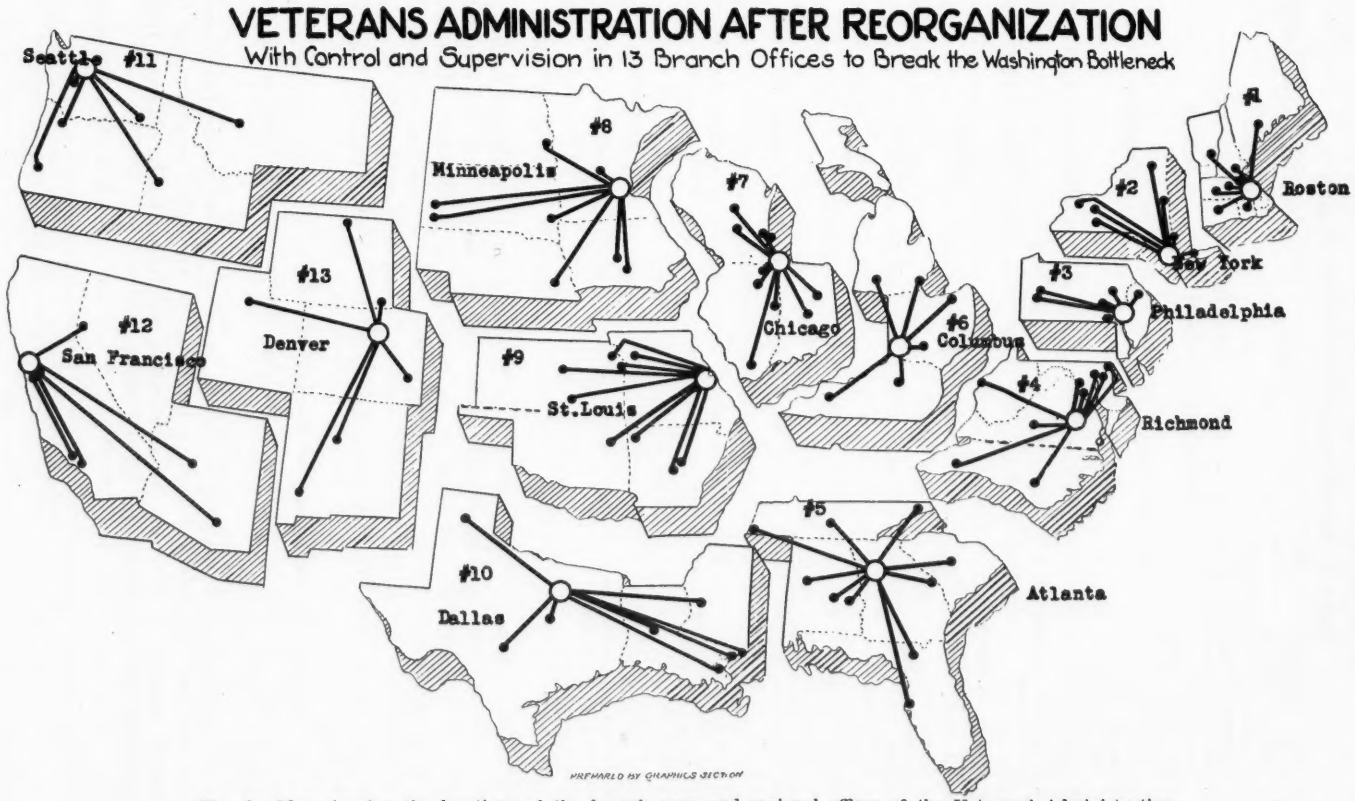

Fig. 2.—Map showing the locations of the branch area and regional offices of the Veterans' Administration.

TABLE I. BRANCH DIRECTORS IN THORACIC SURGERY

NAME AND ADDRESS	AREA	LOCATION OF BRANCH OFFICE
Dr. Gustaf Lindskog Yale University Medical School New Haven, Conn.	1	Boston
Dr. Warriner Woodruff 8 Church Street Saranac Lake, N. Y.	2	New York
Dr. Edward M. Kent University Club Pittsburgh, Pa.	3	Philadelphia
Dr. Everett Drash Univ. of Virginia Richmond, Va.	4	Richmond
Dr. Edward F. Parker, Jr. 70 Hasell Street Charleston, S. C.	5	Atlanta
Dr. William M. Tuttle 307 David Whitney Bldg. Detroit, Mich.	6	Columbus
Dr. Joseph Gale Univ. of Wisconsin Madison, Wis.	7	Chicago
Dr. O. T. Clagett Mayo Clinic Rochester, Minn.	8	Minneapolis
Dr. Thomas Buford Dept. of Surgery, Barnes Hosp. 600 South Kingshighway St. Louis 10, Missouri	9	St. Louis
Dr. Michael DeBakey Dept. of Surgery Tulane Medical School New Orleans, Louisiana	10	Dallas
Dr. Paul Samson 2938 McClure Oakland, California	12	San Francisco
Dr. John B. Grow Fitzsimons Gen. Hosp. Denver, Colorado	13	Denver

The Dean's Committee has authority to nominate for appointment residents, attending surgeons, and senior consultants, and is charged with the responsibility of the educational program in the hospital. It is necessary, therefore, to make application directly to the Dean's Committee for positions in hospitals supervised by the medical schools. The Research and Education Service, directed by Dr. Paul B. Magnuson, is responsible for the Dean's Committee Program.

In hospitals not supervised by medical schools, applications for positions may be made directly to the branch medical director, central office, or to the manager of the hospital.

There is not sufficient time to discuss in detail the various available positions and pay schedules. Complete information concerning opportunities in thoracic surgery in Veterans Administration hospitals may be obtained from the branch director or from the central office.

DIAGNOSIS OF TETRALOGY OF FALLOT AND INDICATIONS FOR OPERATION

HELEN B. TAUSSIG, M.D. (BY INVITATION)*
BALTIMORE, MD.

THE four features which characterize the tetralogy of Fallot are pulmonary stenosis or atresia combined with dextroposition of the aorta, a high ventricular septal defect, and right ventricular hypertrophy.

The characteristic clinical findings are cyanosis and clubbing, a heart of normal size, usually a basal systolic murmur, and a pure second sound. The electrocardiogram shows a right axis deviation. The x-ray shows an absence of the normal fullness of the pulmonary conus and clear lung fields. Fluoroscopy shows no pulsations at the hilar of the lungs.

There are many variables. The systolic murmur may be quite loud or entirely absent. The second sound may be diminished or accentuated; it is never reduplicated. Cyanosis may be marked or slight, depending upon the degree of the oxygen unsaturation and the height of the red blood count. The oxygen saturation of arterial blood is also subject to great variation (from 88 to 10 per cent). It varies from individual to individual depending upon the severity of the pulmonary stenosis, and also in the same individual from day to day. The exercise tolerance of the individual shows a corresponding variation: some persons can walk a mile, some not at all. Operation is indicated for those who are severely handicapped.

The operation is designed to increase the circulation to the lungs. It consists of an anastomosis between the proximal end of one of the systemic vessels to the side of one of the main pulmonary vessels. The operation is indicated only in cases in which the primary difficulty is lack of circulation to the lungs. It is possible only provided there is a pulmonary artery to which to anastomose the systemic artery and provided the pressure in the systemic artery is higher than in the pulmonary artery, and finally, that the size and structure of the heart is such that it can adjust to the altered circulation. Fluoroscopy aids in the determination of the size and structure of the heart. The heart should not be enlarged. There is no fullness of the pulmonary conus and no pulsations in the lung fields. Usually there is an absence of hilar shadows. However, in patients with extensive collateral circulation these shadows may become pronounced but are composed of an aggregate of fine shadows and never show expansile pulsations.

The diagnosis of a right or left aortic arch is of importance because the position of the aorta determines the side upon which operation is performed.

Summary of paper read at the Twenty-sixth Annual Meeting of The American Association for Thoracic Surgery, Detroit, Mich., May 29, 30 and 31, 1946.

*Abstracted at Johns Hopkins Hospital, Baltimore, Md.

A right aortic arch occurs in 20 per cent of the patients with a tetralogy of Fallot. In all such cases the innominate artery lies on the left. Indeed, the innominate, if present, lies on the opposite side to that upon which the aorta descends, and, furthermore, the subclavian artery is given off the innominate artery at a better angle for anastomosis than it is from the aorta. Therefore, the operation is usually best performed on the opposite side from the aortic arch.

The course of the aorta is determined by fluoroscopy or by x-ray. Often the normal aortic knob is visible on the left. The right aortic knob is often hidden with the ribbon of the superior vena cava. Delineation of the esophagus with an opaque barium mixture usually clarifies the position of the aorta. Normally, the esophagus descends in the midline, and is indented to the right on its left margin, whereas if the aorta arches to the right and descends upon the right, it indents the right margin of the esophagus to the left and the esophagus lies to the left of the midline. Normally, in the right anterior oblique position, the esophagus hugs the cardiac shadow and is slightly displaced backward by the aorta, whereas in cases of a right aortic arch, in the right anterior oblique position the esophagus is independent of the aorta.

The factors influencing selection of patients are: (1) age and size of the patient, (2) the severity of the anoxemia, and (3) the height of the red blood count, hemoglobin, and hematocrit.

The optimum age is between 5 and 10 years. The use of the subclavian artery for the anastomosis is sounder and a far less dangerous operation than is the use of the innominate. The subclavian artery in an infant is always extremely small; therefore, operation is not indicated in infancy unless it appears that the infant is going to die.

If, however, the patient is in danger of dying of anoxemia, early operation is clearly indicated. Attacks of dyspnea are common and are often severe between 4 and 18 months of age. Prolonged syncope is an indication for operation.

The degree of incapacity varies greatly. With an oxygen saturation of 30 per cent most children can walk only a few feet. With an oxygen saturation of 20 to 25 per cent few can walk at all. Below 20 per cent is cause for great concern.

The height of the red blood count, hemoglobin, and hematocrit are of importance in the selection of patients. If the red blood cell count is between 8 and 10 million, or hematocrit between 70 and 80 mm. the patient is in great danger of cerebral thrombosis. For such children operation is indicated. Inasmuch as dehydration increases the danger of thrombosis prior to operation, these children should receive 1½ to 2 quarts of liquid a day. Twelve hours of dehydration is liable to cause cerebral thrombosis; therefore, great care should be used not to dehydrate the child the night before operation, especially if not operating early in the morning.

Results of operation are immediate improvement in patient's color, prompt rise in oxygen saturation of arterial blood, and the gradual fall in red blood count, hemoglobin, and hematocrit. The rapidity of the fall of the red blood cell count depends upon the amount of blood lost at operation. Once the anastomosis is established there is no need for the polycythemia. Although heresy to the surgeon, venesection at the end of the operation is sound physiological procedure. It lessens the load placed in the lungs. The heart is not normal. There is a loud, continuous murmur, but the patient looks like a normal individual. It is not yet possible to say how much we have increased the life span of the patient, but certainly his enjoyment of life is greatly increased. There is gradual disappearance of clubbing of the extremities and a great increase in exercise tolerance. The child can measure his activity not in terms of walking a few feet but in terms of miles.

THE TECHNIQUE OF CREATION OF AN ARTIFICIAL DUCTUS ARTERIOSUS IN THE TREATMENT OF PULMONIC STENOSIS

ALFRED BLALOCK, M.D.
BALTIMORE, MD.

THIS paper consists of a discussion of some of the important technical points in the construction of an artificial ductus arteriosus such as Dr. Taussig and I have employed in the treatment of congenital pulmonary stenosis.[1-4] These comments, which are based upon 144 operations* upon patients who were thought to have an inadequate flow of blood to the lungs, are presented with the hope that others may be spared some of the mistakes.

Cyanosis and Disability.—Most of our patients have shown cyanosis even when at rest. It is proper when a new operative procedure is undertaken that one should choose the patients who have the least to lose in case the operation should result fatally. A number of our patients have required more or less constant exposure to a high concentration of oxygen prior to the operation. It is only natural that the mortality rate in such patients will be higher than in those who are not so ill. A few of our patients have had very little visible cyanosis when at rest but have been unable to tolerate exercise. It should be borne in mind that it is mainly the incapacity and not the peculiar color for which the operation is performed. If there is a history of intolerance to exercise, the oxygen saturation of the arterial blood should be determined immediately after limited exertion.

Age of Patient.—The patients in this series have ranged in age from 2 months to 26 years. The youngest patient on whom the operation has been performed successfully was 5 months of age and the oldest was 26 years. The ideal age is between these extremes and probably lies between 3 and 7 years. The upper and lower age limits in which the operation may result successfully have not been determined; patients under 18 months of age should not be operated upon if it is thought that they will survive to a greater age. There are several reasons for this limitation: (1) One can be less certain as to the correctness of the diagnosis in infants; (2) the mortality rate accompanying operation is higher in this age group; and (3) it is frequently necessary in infants to utilize the innominate or the carotid artery rather than the subclavian, and this adds to the danger of the operation.

Anesthesia.—General anesthesia has been induced by the use of inhalation agents in all of the patients. Dr. Lamont and Dr. Harmel have employed cyclopropane with a high concentration of oxygen in most of the operations. Ether with oxygen has been used in a few, and a combination of ether, cyclopropane, and oxygen in others. It has been very gratifying to note that the color of most patients improved when they were anesthetized. It has not

From the Department of Surgery of the Johns Hopkins University and Hospital.
Read at the Twenty-sixth Annual Meeting of The American Association for Thoracic Surgery, Detroit, Mich., May 29, 30 and 31, 1946.
*This number has now reached 450 and a few alterations in technique have been made.

been determined whether this change is due to the fact that the patient becomes quiet and relaxed or whether it is due to the high concentration of oxygen. The former would appear to be more likely.

Intravenous Fluids.—A needle is placed in a vein of the ankle prior to the beginning of each operation, and salt solution, or glucose solution, or both are administered slowly. Both blood plasma and whole blood are available. The latter is given only if the loss of blood is believed to be excessive. Whenever the operative procedure is a proonged one, blood plasma is administered.

Site of Incision.—The patient is placed on his back; the side of the chest on which the incision is to be made is slightly elevated and the incision extends from the lateral margin of the sternum to the midaxillary line. Usually the incision is made beneath the breast. The pleural cavity is entered through the third interspace and the third costal cartilage is divided. A rib spreader is introduced. When working on the left side, one has to take care that the retractor does not press against the heart and interfere with its action.

The present plan is that the incision is made on the side opposite that on which the aorta descends. The reason for this is that it is desirable to gain access to the innominate and its branches, and this vessel lies on the right when the aorta descends on the left and on the left when the aorta descends on the right. When the innominate is exposed, one may usually choose the innominate or its subclavian or carotid branches for anastomotic purposes, depending upon the size of vessel desired. Even more important, since the subclavian artery is the vessel usually chosen, is the fact that the subclavian branch of the innominate makes a much better angle with its parent vessel following the performance of an anastomosis than does the subclavian which arises from the aorta. The side on which the aorta descends can be determined by the method of Bedford and Parkinson.[5] The aorta has descended on the right in 38 of our operative cases, and in these the incision has been made on the left. Dr. Taussig has determined correctly the position of the aorta prior to the operation in all cases.

Exposure of Pulmonary Artery.—After the pleural cavity has been opened and a rib spreader has been introduced, the pulmonary artery is exposed. This step is facilitated when working on the right side by preliminary ligation and devision of the azygos vein. Traction on the ligature on the proximal end of the azygos vein aids in exposure of the pulmonary artery and the mediastinal contents. By the use of sharp and blunt dissection, the right or left pulmonary artery is dissected free of the surrounding tissues and a piece of heavy braided silk is placed around it. The exposure is usually more difficult on the right than on the left. It is necessary to free an adequate length of the vessel and there is no hesitation in opening the pericardium. In the majority of the cases, however, the pericardial cavity has not been entered. After the braided silk has been placed around the right or left pulmonary artery, the main branches of the vessel are exposed. In order to gain added length for the purposes of the anastomosis, pieces of braided silk around these branches replace that around the larger vessel.

After exposure of an adequate length of the pulmonary artery, the pressure within the vessel is usually measured by the use of a needle and a water manometer. If the vessel is small and the pressure within it is obviously low, this test is omitted for fear of damaging the artery. A large pulmonary artery with moderate pulsations does not mean necessarily that the pressure is high or that the flow is great or that the patient will not be helped by an anastomosis. The pulmonary arterial pressure was measured in 68 cases. In 56 of these it was less than 250 mm. of water. The most frequent reading was between 150 and 200 mm. If the pressure is greater than 350 mm., it is my belief that the anastomosis should not be performed unless other evidence points strongly toward the presence of a significant reduction in pulmonary blood flow.

Abnormalities of the pulmonary artery have presented the greatest difficulties that have been encountered. In two patients, one of whom was operated upon, there was a pulmonary artery to the right lung but none to the left. This is shown diagramatically in Fig. 1. The left lung received most of its blood through a branch of the innominate artery. In two patients who died, the right pulmonary artery was small and was posterior and inferior to the superior pulmonary vein and was not found at operation. The pulmonary artery was too small for a satisfactory end-to-side or end-to-end anastomosis in four patients. In at least thirteen patients the right pulmonary artery divided very shortly after its origin from the main vessel. In two instances I mistook the vessel to the right upper lobe for the right pulmonary artery. This mistake will probably be made frequently unless one is aware of the importance of identifying the right main pulmonary artery. It may be necessary to open the pericardium in order to expose it. If after careful freeing of the vessel it appears to be too short for an end-to-side anastomosis, it is advisable to ligate it proximally, to divide it, and to do an end-to-end anastomosis. In freeing the very short and smaller vessels the walls may be so weakened by division of the supporting tissues that it will be difficult if not impossible to perform a satisfactory end-to-side anastomosis.

In patients in whom the pulmonary artery is in an abnormal position or is absent, the superior pulmonary vein may be mistaken for the artery. I have had this unfortunate experience in two cases, although in both instances it was realized that the course of the vessel was that of a vein. Pulmonary edema and death resulted following the making of an anastomosis. If in doubt as to the nature of the vessel one should open the pericardium, but even then it may be difficult to be certain.

If it is decided after freeing the right or left pulmonary artery that the diagnosis is correct and that the structures are suitable for an anastomosis, the systemic artery that is to be used is exposed.

Exposure of Systemic Vessel.—The mediastinal pleura between the vagus and phrenic nerves is incised. When working on the right side, one should divide the mediastinal structures immediately beneath the superior vena cava. In patients with a good deal of collateral circulation to the lungs, this area is

usually quite vascular and a number of vessels must be ligated. The innominate artery can usually be palpated just to the left of the trachea. After some of the tissues surrounding it are freed, a piece of umbilical tape is passed around the innominate artery by the use of a curved clamp. Traction on this tape and further sharp and blunt dissection will reveal the point at which the innominate divides into the common carotid and the subclavian arteries. If the innominate artery is to be used for the anastomosis, the first portions of the carotid and subclavian arteries are ligated, the proximal part of the innominate is occluded with a bulldog arterial clamp, and the innominate is cut across just proximal to the ligatures on its branches.

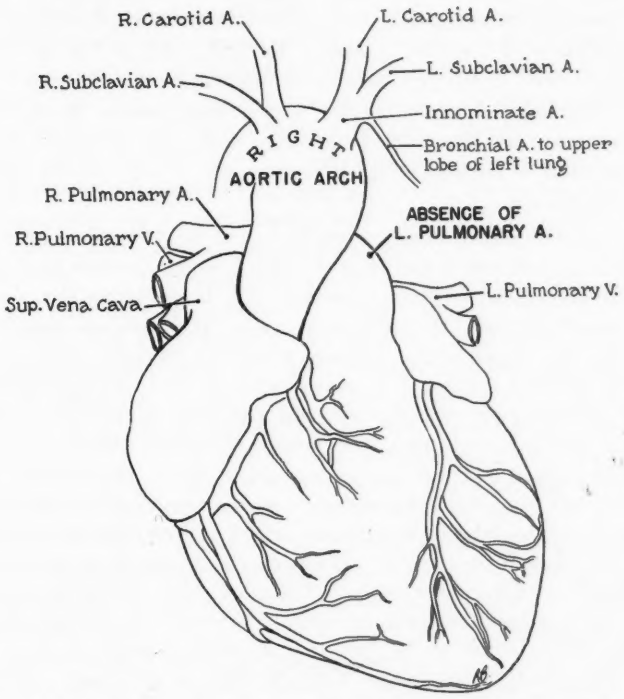

Fig. 1.—Showing the absence of pulmonary artery to the left lung. A branch of the innominate artery passed to the hilus of this lung.

It is highly desirable to use the subclavian artery rather than the innominate if its size is such that it will supply an adequate flow of blood to the lungs. It is now being used in the great majority of cases. The pleura overlying the subclavian artery is incised and a greater length of the vessel is exposed. The anatomical feature which makes it most difficult to expose the subclavian artery is the position of the vagus with its recurrent branch as it passes over the vessel. In some instances the vagus is pulled medially and the sub-

clavian is exposed lateral to it. Usually, however, this maneuver is not necessary. The subclavian artery is ligated at the point where it gives off its first big branch, its proximal part is occluded with a bulldog arterial clamp, and the vessel is cut across proximal to the ligature. The section of the vessel is usually made in an oblique direction in order to expose the circumference of the end.

In an occasional patient the subclavian artery is so short that an anastomosis is difficult or impossible. This difficulty may sometimes be overcome by occluding both the innominate and carotid arteries temporarily with arterial clamps and removing the clamp from the subclavian artery. This step leaves the entire length of this latter vessel free for anastomotic purposes. However, even this maneuver may not give an adequate length of vessel. Under such circumstances it may be necessary to ligate and divide the subclavian artery, to ligate and divide the common carotid artery as high as possible, and to use the proximal end of the carotid for the anastomosis. It should be emphasized, however, that the carotid should be used only when the employment of the subclavian is impossible for it exposes the patient to the danger of a cerebral complication.

Regardless of which systemic vessel is chosen, the rubbershod arterial clamp with which it is occluded is tied in place with a heavy ligature around the two arms. This accomplishes two purposes: (1) It prevents the clamp from becoming dislodged, and (2) it affords a means by which one may make traction and thus approximate the systemic artery to the pulmonary artery. If, after having divided the systemic artery which is to be used, it appears that the arterial clamp is too near the free end, one may usually place another arterial clamp proximal to it and then remove the distal clamp.

As stated previously, the innominate artery arises on the left and is directed to the left when the aorta descends on the right. After the mediastinal pleura has been divided the innominate artery can usually be found without difficulty even though the superior vena cava is not present on the left to serve as a landmark. As a matter of fact, the most easily performed anastomosis is usually that in which the aorta descends on the right and the incision is made on the left. This is due to the fact that a greater length of the pulmonary artery is more easily accessible on the left than on the right. Furthermore, early branching of the left pulmonary artery is less likely to be encountered.

In every patient who has been explored there has been a branch of the arch of the aorta which could be used for the anastomosis. Such branches have not always been of the ideal size or length, but at least one or another could be used. This statement is not meant to imply that there have not been variations. For example, as far as could be discerned there was no innominate artery in twelve cases. It appeared that the four large vessels arose separately from the arch of the aorta. It was my impression that both common carotid arteries as well as one of the subclavians arose from the innominate very close to the arch of the aorta. At any rate, the fact that a second carotid arose from the innomi-

nate did not interfere with the use of the latter vessel or the subclavian for the anastomosis. In five patients the subclavian artery on the side of the operation arose directly from the aorta and passed posterior to the esophagus. This abnormal position did not interfere with the use of this artery for the anastomosis. This type of anatomical variation is shown in Figs. 2 and 3.

At times difficulties were encountered which were due to the short length of the systemic artery which it seemed desirable to use. A very short innominate artery was present in twelve cases. In fourteen other cases the subclavian branch of the innominate artery was quite short. It is significant, however, that there was in all instances a systemic artery which could be used for the anastomosis. In some cases the arteries were shorter or smaller than was desirable but nevertheless some systemic vessel could be used. The situation in this respect has been more satisfactory than that in connection with the variations in length and size of the pulmonary arteries. As stated previously, the carotid artery may be used if the innominate and the subclavian arteries are too short, but this is very undesirable and is rarely necessary.

In our earlier patients the innominate artery was used in a number of cases in which the subclavian artery would probably have been a better choice. Most children over the age of 2 have a good sized subclavian artery and one that is capable of transmitting a large quantity of blood. The subclavian should be occluded temporarily near its point of division in order to obtain a good idea as to the size of the vessel. The subclavian artery is being chosen more frequently and the innominate less often.

A few words may be in order regarding abnormalities of the superior vena cava. In two patients the superior vena cava was located on the left side but it entered the right side of the heart. In another, the superior vena cava was not visualized in the right side of the chest and it is assumed that it was on the left. In two patients a right superior branch of a pulmonary vein was connected to the superior vena cava.

The Anastomosis.—There are a number of reasons why an anastomosis of the end of a systemic artery to the side of one of the pulmonary arteries is to be preferred to an end-to-end suture, despite the fact that the former is more difficult. Among these are: (1) An end-to-side anastomosis allows the shunted blood to pass to both lungs; (2) the size of the opening into the side of the pulmonary artery may be made to correspond very closely in size to that of the end of the systemic artery, whereas there may be much discrepancy in an end-to-end anastomosis; (3) if following an end-to-end anastomosis in a patient who has atresia or marked stenosis a collapse of the lung develops on the side of the operation, the limited flow of blood through the opposite lung may not be sufficient to maintain life; and (4) if an end-to-side anastomosis is performed and if later in life the pulmonary blood flow appears to be inadequate, the operative procedure may be repeated on the opposite side, whereas it may not be possible to do this if an end-to-end anastomosis has been performed. If one of the pulmonary arteries is divided and an end-to-end anastomosis is made, it is doubtful whether the patient would tolerate occlusion

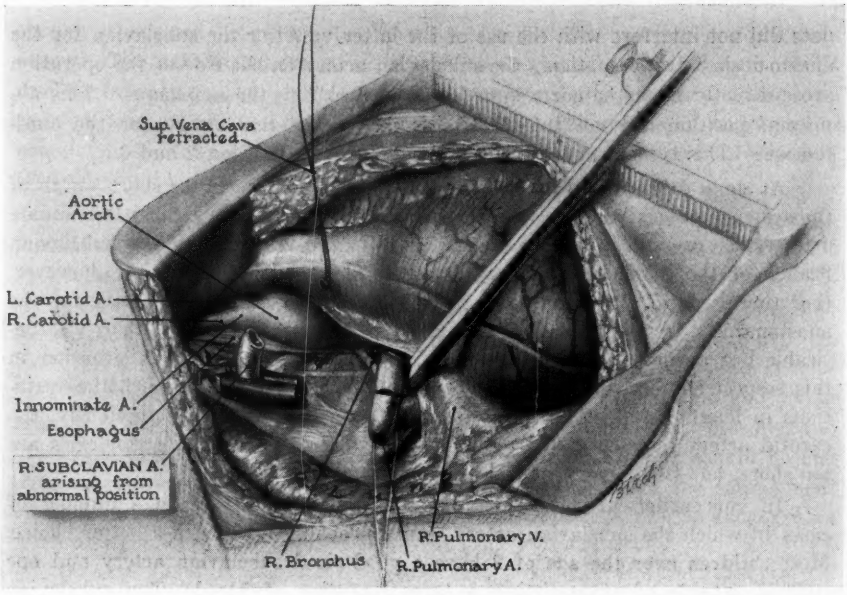

Fig. 2.—Showing a subclavian artery on the right which arose from the aorta rather than from the innominate and which passed posterior to the esophagus. Both carotids arose from the innominate.

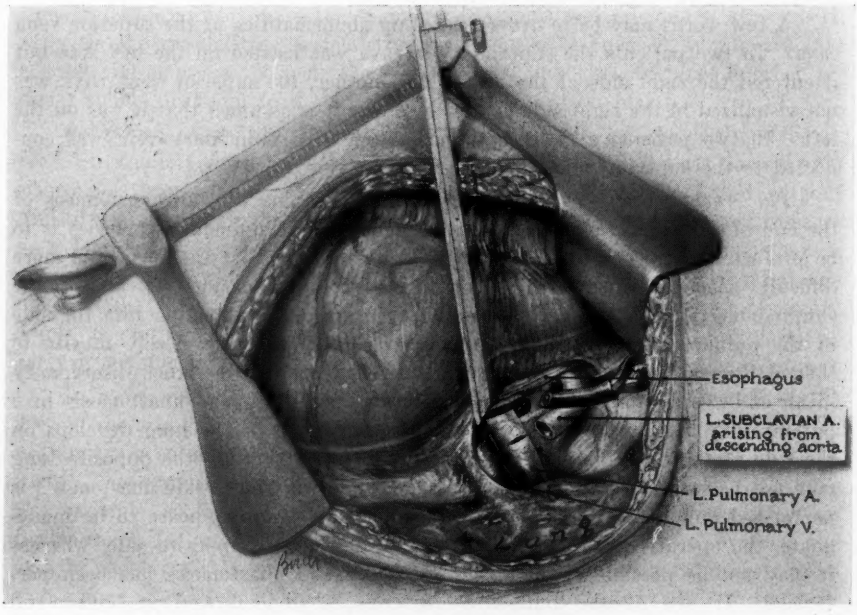

Fig. 3.—Showing the left subclavian artery in a patient with a right aortic arch. This vessel arose directly from the aorta instead of from the innominate and passed posterior to the esophagus.

of the opposite pulmonary artery for the length of time that is necessary for the accomplishment of an anastomosis. Despite these objections to an end-to-end anastomosis, it must be said that very dramatic results have followed the use of this method in most cases in which it has been used. Points in its favor are: (1) it may be performed more easily and quickly; (2) it may be used when there is a very short pulmonary artery and an end-to-side anastomosis is difficult or impossible; and (3) traction on the mediastinal contents is lessened. All things considered, however, the end-to-side anastomosis is preferred and has been used in most of the operations.

After the pulmonary artery has been dissected free of the surrounding tissues and after the systemic artery has been made ready, final preparatinos for the anastomosis are made. My remarks will be limited at this point to the end-to-side anastomosis. The right or left pulmonary artery is occluded proximally with a mechanical device, the tips of which are covered with rubber. This instrument has a long handle which makes it useful in stabilizing the mediastinum and in approximating the pulmonary artery to the systemic vessel. A photograph of two of the instruments is shown in Fig. 4.* Distal occlusion of the pulmonary artery is produced by traction on the pieces of braided silk which have been placed around the branches of the pulmonary artery. If the artery is unusually long, bulldog arterial clamps are placed on the branches. After proximal and distal occlusion has been produced, a transverse opening is usually made in the pulmonary artery between the points of constriction. This opening is made slightly bigger than the circumference of the end of the systemic vessel. Some of the adventitia surrounding the opening in the pulmonary artery is excised, but the pulmonary artery should not be weakened too much by removal of the adventitia around the entire circumference of the vessel. If the pulmonary artery is very much smaller than usual and if an end-to-side anastomosis is to be attempted, the opening in the artery should be in a longitudinal rather than a transverse direction.

After the incision in the pulmonary artery has been made, the anastomosis is begun. The suture material which has been employed in most of the operations is 00000 silk on small round needles (Deknatel). The suture is essentially a continuous one in which intima is approximated to intima. The suture includes the entire thickness of the wall of the artery. An attempt is made to place the sutures 1 to 2 mm. apart and approximately two-thirds of the posterior row is placed before the suture is drawn taut. Each end of this running suture is then tied to interrupted sutures which are placed at appropriate points. The continuous suture is begun again and the posterior row is completed, at which point another interrupted suture is placed. The anterior row of sutures is easier to place. It is usually interrupted at one additional point. The suture around the entire circumference of the anastomosis is in reality a single row of a continuous out-in and -over suture which everts intima and which is interrupted in several places in order not to constrict the lumen of

*Made in three sizes by the Murray-Baumgartner Company, 5 West Chase Street, Baltimore, Md.

the opening. It is just the opposite of the in-out and-over suture which is frequently employed in intestinal anastomoses in inverting the intestinal mucous membrane.

After completion of the anatomosis, the traction on the braided silk around the branches of the pulmonary artery is released and the instrument which has been used in occluding the pulmonary artery proximally is removed. If a spurting stream of blood comes from some point along the suture line, an additional suture is placed. If there is simply a slow ooze of blood, slight pressure is made and it will usually stop without the use of further sutures. Several minutes after all bleeding has ceased, the arterial clamp is removed from the systemic vessel. Usually no further bleeding occurs. If there is bleeding, the arterial clamp is replaced and the suture line is inspected again.

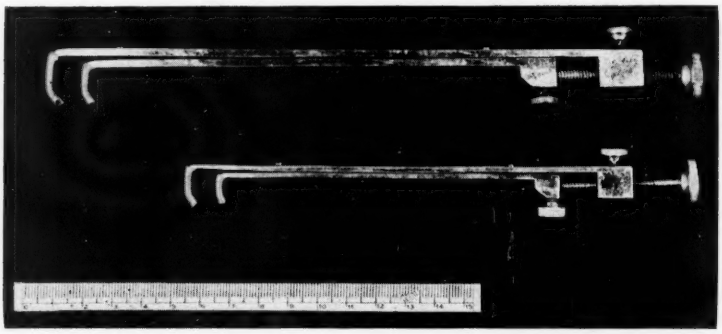

Fig. 4.—Showing two sizes of clamps which may be used for producing temporary occlusion of the pulmonary artery.

After the anastomosis has been completed and the constricting devices have been removed, a continuous thrill can usually be felt in the pulmonary artery. In many cases this can also be felt in the lung tissue at a considerable distance from the hilus. In infants and even in older children one may not feel a satisfactory thrill if the systemic arterial pressure is low.

After every effort has been made to be certain that the anastomosis is patent, including gentle massage of the opening, the mediastinal pleura is closed with interrupted sutures. The retractor is removed and the lung is partially inflated. Usually by this time the color of the patient has definitely improved. The third and fourth ribs are approximated with an encircling interrupted suture of braided silk or of some smaller material. The tip of a catheter is placed temporarily in the pleural cavity. The muscle, fascia, subcutaneous tissues, and skin are approximated with interrupted sutures of silk. Aspiration is carried out and the catheter is removed.

As indicated previously, it is necessary or at least advisable in an occasional patient to perform an end-to-end anastomosis between the proximal end of a systemic artery and the distal end of one of the two pulmonary arteries. This is somewhat easier than the end-to-side anastomosis. After choosing the parts

of the two arteries which should be opposite each other, three interrupted sutures are placed at equidistant points. A continuous everting suture is then used in connecting these points.

Postoperative Treatment.—The patient is placed in an oxygen tent immediately after operation. The length of time that the administration of oxygen is continued varies from a few hours to a number of days. Penicillin therapy, which had been begun prior to operation, is continued for at least several days. The intravenous needle is left in place until the patient begins to take adequate fluids by mouth. The patient should be given adequate but not excessive fluids. If the arterial blood pressure declines, an immediate effort should be made to raise it by the giving of plasma or whole blood, because otherwise cerebral thrombosis or closure of the anastomosis might occur. If the patient presents evidence of weakness of the side of the body opposite the operation, heparin is given; otherwise, anticoagulants are not used. Dicumorol was given to the earlier patients in this series but its use has been discontinued. The patient is observed carefully for evidence of the accumulation of air or blood in the pleural cavity and aspiration is performed if indicated. If evidence of heart failure develops, a digitalis preparation is given.

In most patients the postoperative period is remarkably uneventful but in others it is very stormy. If death occurs, it is usually in the first forty-eight hours after operation. Some of the patients have been discharged from the hospital on the twelfth postoperative day, whereas others have remained in for considerably longer periods.

SUMMARY

The technique by which one may create an artificial ductus arteriosus in the treatment of pulmonic stenosis has been described. The ages of the patients have ranged from 2 months to 26 years. Operation has been performed on 144 patients with an over-all mortality rate of 22 per cent. This total includes several patients in whom the pulmonary artery was absent or was so abnormal that it could not be found at the time of operation.

An anastomosis was performed between the end of a systemic artery and the side of one of the two main pulmonary arteries in 118 patients with eighteen deaths, a mortality of 15 per cent. The subclavian artery was used in seventy-two of these with five deaths, a mortality of 7 per cent. The carotid artery was used in eleven cases with one death, a mortality of 9 per cent. The innominate artery was employed in thirty-six patients with twelve deaths, a mortality of 33 per cent. I have practically abandoned the use of the innominate artery in patients 2 years of age and older.

An end-to-end anastomosis was attempted in thirteen patients and there were six deaths. In five of the fatal cases the pulmonary artery was too small for a satisfactory anastomosis. In the remaining case the child was improved following operation but death occurred suddenly six months later from an unexplained cause.

With one exception, all of the patients in whom an anastomosis was performed and who are living are believed to be improved. In this patient the intima of the subclavian artery was damaged and thrombosis occurred. There has been no mediastinitis, no empyema, no severe bleeding from the anastomotic line, and thus far no bacterial endarteritis.

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DISCUSSION ON "THE TECHNIQUE OF CREATION OF AN ARTIFICIAL DUCTUS ARTERIOSUS IN THE TREATMENT OF PULMONIC STENOSIS" BY DR. ALFRED BLALOCK, AND "DIAGNOSIS OF TETRALOGY OF FALLOT AND INDICATIONS FOR OPERATION"

BY DR. HELEN B. TAUSSIG*

DR. GEORGE H. HUMPHREYS: After Dr. Taussig's and Dr. Blalock's brilliant lead last spring, Dr. Arthur Blakemore and I tried this same operation, or the same type of operation, on a group of patients at Babies' Hospital.

Of the ten patients, we have lost three. One of them, lost in the postoperative period, was the first case, and I believe we handled it incorrectly by giving blood. As Dr. Taussig has stated, perhaps these children should have a venesection rather than a transfusion.

The other two children were very severely cyanotic and were lost on the table before the anastomosis was even begun, one of them because of an anomaly which made us take a good deal of time in dissecting out the subclavian, which passed behind the esophagus with no innominate.

The other one apparently was a straight anoxic death, possibly due to the fact that it was necessary to divide many tortuous anastomotic vessels in exposing the pulmonary artery.

At autopsy this child had practically no lumen at all in the pulmonary artery. A probe could barely be passed through the stenotic vessels. It seems possible that all the pulmonary blood flow passed through the anastomotic vessels, many of which had to be tied to expose the pulmonary artery.

The seven who survived have done well. In one we went in on a right aortic arch which we did not recognize on the right, with an anastomosis with the subclavian and probably too small a lumen to help as much as we would have liked.

Four others have done far better, two of them with subclavian and two of them with innominate anastomoses.

The fifth case was a left subclavian anastomosis, done because the child had had previously a left hemiplegia, and we didn't want to risk a right hemiplegia following operation.

Two of the children did develop hemiplegias. Very probably fluid therapy was inadequate and they may have been dehydrated. We believe these hemiplegias were not due to tying off the carotid artery, although both children had innominate anastomoses, because the hemiplegia did not develop until several days after the operation.

I am happy to say that both of them have recovered almost fully from their hemiplegias.

*See page 241 for article by Taussig.

DISCUSSION

DR. E. J. O'BRIEN, Detroit, Mich.—My visit to the clinic of Dr. Taussig and Dr. Blalock was the most amazing experience in my life. I was so fascinated with the work of both that I was most anxious that they should present it here. I especially wanted to have them show the necessity of close co-operation between a Cardiologist, Roentgenologist and the Surgeon and I am sure they both made that clear.

DR. F. C. FISHBACK, Washington, D. C.—It seems proper to speak briefly not about the surgical or physiological aspects of the surgical treatment of the tetralogy of Fallot, but about its probable political influence. Dr. Blalock has just mentioned a beginning antivivisection campaign here in Detroit. We can thank Dr. Blalock for his great help in defeating the last antivivisection bill before Congress by his testimony in which he pointed out that the successful evolution of this procedure and its performance was based on the use of dogs as experimental animals. It is appropriate to remind you that this year, 1946, marks the fiftieth anniversary of the introduction of the first antivivisection bill in Congress. Lest we become complacent and apathetic, it is well to recall that just such a bill actually passed the House of Representatives in 1900 but was killed in committee in the Senate. You are all familiar with recent antivivisection proposals notably in New York and Massachusetts, and last year in Baltimore and Chicago. The effectiveness of testimony concerning this type of surgery in counteracting and combating the false emotionalism and dishonest appeal of the antivivisectionist was never better exemplified than before the House Committee in February of this year. Dr. Blalock told his story simply and lucidly, and presented three of his young patients. The day before the hearing, the father of one of these little boys called me and asked if he had to make a speech. On my assurance that all he need do would be to answer Dr. Blalock's questions, I suggested that if he were asked, "How blue was your son?" he might well answer, "As blue as my uniform." The father had been a sailor. At the hearing, when Dr. Blalock asked this question, the father replied, "As blue as my suit—why, he even looked as though he had been eating blueberry jam." This remarkable work speaks for itself, but the telling of it before legislative bodies is equally important if we are to remain free to use animals for the benefit of mankind and surgical progress.

DISCUSSION OF MOTION PICTURE PRESENTATION ON "THE SURGICAL TREATMENT OF COARCTATION OF THE AORTA" BY DR. CLARENCE CRAFOORD

DR. ROBERT E. GROSS, Boston.—Our interest in this work began before the war, in the hope of trying to find a way in which a portion of a narrowed aorta could be removed. We wanted to know two things: first, could the aorta be cut in half and sewed together again; the answer to that was in the affirmative; second we wanted to know if a segment of aorta 1 or 2 cm. in length could be removed, and whether there was enough elasticity in the remaining vessel to get the ends of the aorta together. In normal dogs we found that such a segment could be cut out and the aortic ends could still be anastomosed.

With a few slides I think we can show our technique. (Slide.) All of these experiments were on dogs. Going through the left side of the back, the aorta was exposed. In the region where we might expect a coarctation (in humans) two clamps were put on the aorta and the aorta was severed, or a short piece was excised.

(Slide.) Dr. Crafoord has used the end-to-end suture with an exact anatomic reconstruction of the vessel. In the first part of our work we tried such anastomoses. A number of them ruptured, and I felt that they were not the best type of suture. However, Dr. Crafoord has reported excellent results with the method. Still, it is a little hard for me to overthrow our experimental work which would seem to indicate that an everting type of suture is far superior.

When the aorta is cut in half and the clamps are in place, the aorta is rotated forward, because it is easier to perform the posterior part of the repair first. That is done with a Deknatel 5-0 silk suture on an atraumatic needle. The suture is a continuous mattress one. When the back surface is completed, the aorta is rotated into a normal position, so that the suture can be continued anteriorly and eventually the thread can be tied to its original end. When the anastomosis is finished, intima comes to intima and the ends of the vessel are turned outward.

After a number of experiments on dogs we felt that this was the best type of aortic suture that we could find.

(Slide.) Here is a specimen removed from one of these dogs, sacrificed some months after operation. Here is the descending aorta, from which a segment of aorta 2½ cm. in length had been removed. This is merely to show you that the healing of the aorta is satisfactory after one of these anastomoses.

(Slide.) Here is the same specimen, injected under pressure with an iodide solution and a roentgenogram taken to show the size of the lumen of the vessel. The lumen of the aorta is actually larger at the site of the anastomosis than it is above or below that level.

(Slide.) Our technique differs in another way from Dr. Crafoord's. As he indicated, he did not divide the intercostal arteries. I think that he has a good academic point, but from the practical angle I don't believe that it is of great value to preserve these few collateral vessels. I have felt that I wanted to get everything out of the field that could be cleared away, and hence we have not put clamps on these vessels. Instead, we have divided two sets of intercostal arteries, below the coarctation. (The absence of clamps gives the operator more freedom in the field during the subsequent delicate steps of the aortic anastomosis.)

The segment of the aorta, about three inches in length, is raised from its bed and freed from surrounding structures. Two clamps are placed on the aorta and the narrowed part of the vessel is cut out. In two of our patients there was no opening in the excised specimen; in the other six individuals there was a tiny opening 2 or 3 mm. in diameter.

My experience in eight cases may be summarized briefly. There were two deaths. The first fatality occurred as the last aortic clamp was removed. I assume that the readjustments were too fast: the patient expired immediately. In all subsequent cases, the clamps were removed very slowly, so that the readjustment is made slowly over a period of three to five minutes, and there has been no apprehension in any of these cases. The second death was

in an individual 30 years of age, who possibly should not have been operated upon. The man had severe pain in the back, with dilatation of the lower aortic segment. The lower segment was very thin and an anastomosis was performed which did not seem to be very satisfactory because of the thinness of the aortic wall. The individual died twenty-four hours later, presumably from hemorrhage at the site of anastomosis. Of the remaining six individuals, there is one in whom the anastomosis was not ideal, and there has been only slight reduction of his arterial pressure. The remaining five patients have had a very dramatic drop in arterial pressures in the upper part of the body and a development of good pulsations in their legs.

These pressure changes did not take place immediately. Apparently the vascular system in the lower part of the body is smaller than normal, or has an increased vascular tone. Suffice it to say that it takes a period of time—ten days to two weeks—to dilate the vascular bed in the lower part of the body.

Again, I would like to thank Dr. Crafoord for coming here to give us his presentation, and to bring us greetings from the medical profession of Sweden.

DR. CLARENCE CRAFOORD, Stockholm, Sweden.—In connection with a demonstration of a colored film showing an operation for coarctation of the aorta, it was pointed out that all eight patients were operated upon with one death. The fatal outcome in this case was due to hemorrhage from a divided and tied intercostal artery which took place four hours after operation. At postmortem it was demonstrated that the hemorrhage was due to cutting through of the linen ligature on the intercostal artery near the aorta. All the other cases have healed and seem to go back to normal blood pressure conditions.

Referring to the explanation of the sudden death when the clamp was removed in Dr. Gross's case, I have not seen anything of that kind in any case that I have operated on, in spite of the fact that I have removed the clamps very fast in all my cases.

In addition to that, I have, in about thirty-five cases of patent ductus, applied clamps above and below the duct, excising the duct out of the wall of the aorta, and in those cases I have removed the clamps without delay and have never had any difficulty.

AN ENDOBRONCHIAL BALLOON FOR THE CONTROL OF BRONCHIAL SECRETIONS DURING LOBECTOMY AND PNEUMONECTOMY

JAMES D. MOODY, M.D., JOSIAH C. TRENT, M.D., AND GEORGE W. NEWTON
DURHAM, N. C.

THE rapid progress in the development of surgical methods for the treatment of suppurative pulmonary diseases has made the need for adequate control of bronchial secretions during operation increasingly apparent. In a recent report of seventy-six cases of bronchiectasis treated by lobectomy or pneumonectomy, Bradshaw and O'Neill[1] record twelve deaths, six of which could be attributed to the transbronchial aspiration of pus expressed from the diseased lobe. Overholt and Wilson[2] report forty-five resections performed for pulmonary tuberculosis since 1942; contralateral spread occurred in 11.1 per cent. He states, "Contralateral spread is still the greatest hazard of pulmonary resection." Further reports serve only to substantiate the fact that it is a well-known and troublesome problem, especially for the anesthetist concerned with thoracic surgery. It is the purpose of this paper to present a new instrument for the control of bronchial secretions during the removal of infected lobes and to describe its successful use in experimental animals.

HISTORICAL

Most of the work in this field has been directed along three lines: namely, a catheter in the bronchus of the affected side for aspiration of secretions, a balloon in the affected side for obstruction of the secretions, or a combination of these two. Although aspiration by catheter has been in use for some time, possibly the first important step was made when Gale and Waters[3] in 1931 devised an endotracheal airway fitted at its distal end with a thin rubber cuff. The airway was inserted into the stem bronchus of the sound side and the cuff inflated so that it blocked both main bronchi at the carina. The most obvious criticism of this method was that the balloon could not be depended upon to block the affected lobe in lower lobe bronchiectasis; and, since there was no means of aspirating the pus, it could drain into the sound upper lobe. This method could be used satisfactorily, however, in pneumonectomy. In 1934, Archibald[4] reported seven cases in which he had successfully occluded the bronchus to the affected lobe by means of an inflatable balloon on a long coudé catheter. We have found that such a catheter cannot be depended upon to stay in place. Two years later Magill[5] devised a combined tracheoscope and anesthetic tube through which was inserted a suction catheter bearing an inflatable balloon. The anesthetic tube could be fitted with a cuff to hold it in place in the trachea while the balloon was placed in the stem bronchus. We have had no experience

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with this instrument, but it is our opinion that the balloon may be easily dislodged during operation. In 1941, Nosworthy[6] described the use of a balloon-endotracheal catheter to be used for pneumonectomy. This was inserted into the main bronchus on the sound side. Nosworthy noted the lack of a suitable instrument for use in lobectomies. He also mentioned Crafoord's[7] technique of bronchial tamponade for both pneumonectomy and lobectomy. This consisted in packing the stem bronchus with ribbon gauze kept in place by a wire rod; over this was threaded an endotracheal catheter. The most serious objection to these instruments and all others devised to date is their tendency to slip out of place at inopportune times; this obviously constitutes a serious hazard.

Many of the criticisms of these methods and of others not mentioned have been summarized in Beecher's[8] discussion of anesthesia in thoracic surgery. He recommends an endotracheal catheter made airtight at the face mask, the Trendelenburg position, and tracheobronchial suction by catheter. Blades and Graham[9] depend upon the upright position during operation to prevent secretions from entering the upper lobes. This method has been successful in seven cases, but they themselves raise the objection that in event of shock the head would have to be lowered; hence bronchoscopic aspiration would be necessary at once.

Thus it is apparent from the preceding discussion that there is still a need for some technique or instrument which will prevent the flooding of unaffected lobes with pus during operation.

CONSTRUCTION

After reviewing the methods tried in the past, it was decided that the most practical way to occlude the bronchus was by means of a balloon. We have therefore devised a double-lumen balloon-suction catheter (Fig. 1) for use in pneumonectomies and lower lobectomies. Early in our experimentation it was decided that it would be more practical to devise two instruments, one for obstruction of the lower lobes, and one for obstruction of the upper lobe, rather than to attempt to incorporate the necessary functions of both in one instrument. The instrument described in this report occludes the affected bronchus with a balloon retained in place by a special holding device, and provides aspiration distal to the balloon. The details of construction are as follows: The catheter is a double-lumen tube of the Miller-Abbott type, 4 mm. in diameter (12 French). At one end is mounted a small cylindrical balloon* approximately 6 mm. in diameter, 0.25 mm. in thickness, and 15 mm. in length. The balloon is inflated through one side of the double-lumen tube. The other lumen of the tube passes through the balloon and ends in a small perforated metal tip. Around the balloon is a small holding apparatus made of beryllium copper especially selected because of its flexibility, strength, and elasticity; this can be transferred within a few seconds from one balloon catheter to another. The over-all length of the assembled balloon, holding apparatus, and suction tip is 25 mm.; only the distal 10 mm., however, are in contact with the bronchial wall. As

*We are greatly indebted to the Miller Rubber Sundries Division of the B. F. Goodrich Co., Akron, Ohio, for supplying the balloons.

will be noted in Fig. 2, the distal end of each strip of the holding apparatus is doubly split, forming three projections, the middle one of which has a 1 mm. point. On inflating the balloon (Fig. 2, B) the points of the middle projections are pushed out into the mucosa, while the lateral projections are flattened out. When the balloon is deflated, all the projections spring back to their original positions, thus disengaging the points from the bronchial mucosa. On withdrawal of the deflated balloon, the two lateral projections protect the mucosa against the points of the middle projections. We first inflated the balloons with air. This was abandoned because of the danger of a sudden explosive rupture of the balloon. Water under mercury pressure was later adopted and found to be more satisfactory.

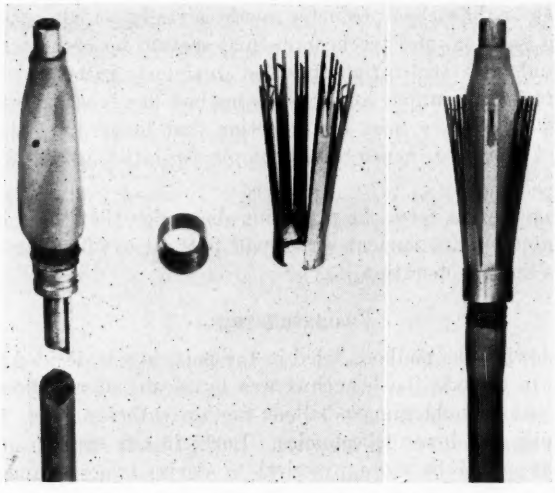

Fig. 1.—Authors' endobronchial balloon, consisting of a double-lumen tube with suction tip and balloon, surrounded by a holding apparatus.

In order to facilitate placement of the balloon in the bronchus, a brass carrier tube 50 cm. in length was devised, the distal 2 cm. of which was widened to fit snugly over the balloon and holding apparatus. This tube, which was threaded over the catheter, held the balloon encased in its tip. After the balloon was placed, a stylet of piano wire was used to dislodge it from the carrier tube.

The proximal end of the double lumen catheter is connected by a small, simple sleeve valve to the manometer and suction systems; the connection between the catheter and the two systems can be opened or closed by means of this valve (Fig. 3). It also affords a way of detaching the double lumen catheter from the pressure and suction systems and maintaining the pressure in the balloon; this facilitates quick removal of the bronchoscope following placement and inflation of the balloon. The entire apparatus including the sleeve valve will pass through a smooth bore 7 mm. bronchoscope.

PROCEDURE

Experimental operations were performed on a series of fifteen mongrel dogs, weighing from 22 to 54 lbs.

With minor variations, the following procedure was carried out in each dog. Anesthesia was produced by pentobarbital given intravenously in dosages of 30 mg. per kilogram. The tongue, pharynx, and larynx were anesthetized locally with pontocaine, and the site was selected for the balloon by bronchoscopy. The carrier tube holding the balloon and catheter was then inserted through the bronchoscope, projecting from its distal end a distance equal to the length of the balloon. Following this, the stylet was run alongside the catheter until it impinged on the base of the holding apparatus; with the balloon thus steadied, the carrier tube was withdrawn into the bronchoscope, leaving the balloon in place in the bronchus. The balloon was then inflated to the proper size as judged by the amount of water injected and the pressure in the manometer. With the manometer tube clamped, the sleeve valve was closed and the double lumen catheter was disconnected from the pressure and suction systems.

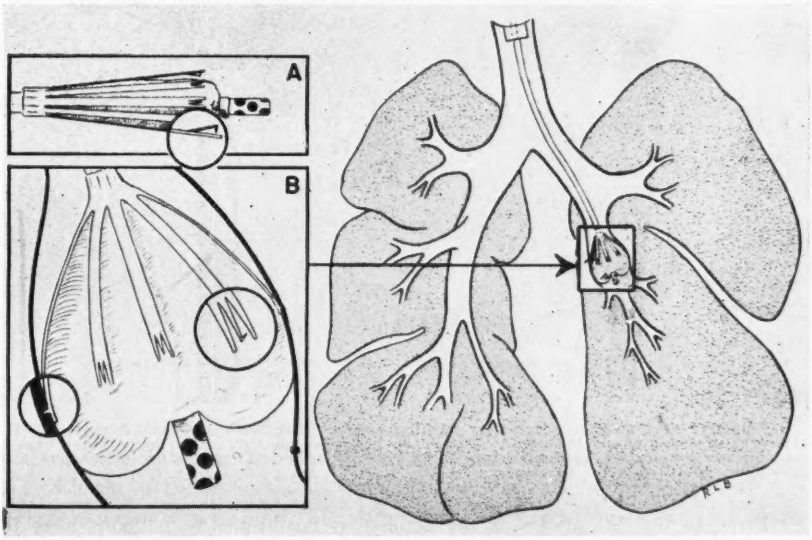

Fig. 2.—Diagram of balloon in lung specimen of a dog: (*a*) position of middle projection and point of each strip of holding apparatus when balloon is deflated; (*b*) inflated balloon showing the three projections of each strip, and lateral view of point embedded in the wall.

The bronchoscope, carrier tube, and stylet were then removed; an endotracheal tube, fitted with an inflatable cuff and attached to a metal T-tube, was slipped over the catheter, which was then reconnected to the manometer and suction systems. Suction was then applied, and atelectasis of the obstructed lobe or lobes was assumed complete when air ceased flowing through the suction bottle (Fig. 4). With the dog under positive pressure respiration, the lobe or lobes were removed using the individual ligation technique for the hilar vessels. After isolation of the bronchus was complete, the balloon was deflated and quickly pulled out through the endotracheal airway. The operator clamped the bronchus as he felt the balloon deflate and slip out. The wound was then closed and after voluntary breathing had resumed, the dog was turned over, and the procedure repeated on the opposite side.

A total of twenty-seven operations was performed on fifteen dogs including twenty-two lobectomies and five pneumonectomies, with no operative deaths.

EXPERIMENTAL RESULTS

At the beginning of this study it was apparent that the instrument must meet certain qualifications. It must: (1) have no harmful effects; (2) completely occlude the bronchus; (3) remain securely in place during operative manipulations; (4) have a wide margin of safety in its construction and operation, allowing complete control at all stages; (5) interfere as little as possible with anesthesia.

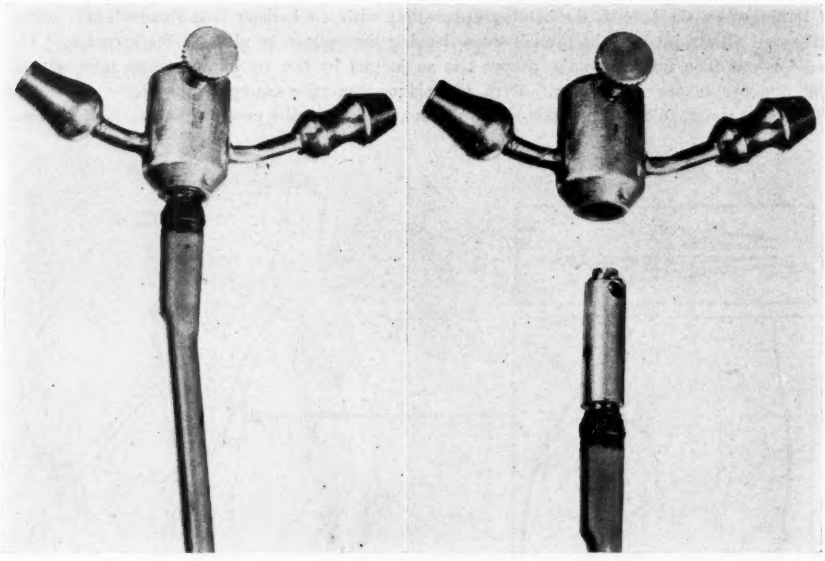

Fig. 3.—Sleeve valve and casing connecting balloon to pressure and suction systems. The valve is opened and closed through a 90° turn by means of the lock-screw in the outer casing; with the screw unlocked, the valve may be disengaged while still remaining closed and thus maintaining pressure in the balloon.

First, to test the effects of the balloon in the bronchus, balloons were inflated in the bronchi of two adult dogs anesthetized with pentobarbital and were allowed to remain in place for seven hours with the suction side of the tubing obstructed. Except for a slight bronchial irritation and consequent coughing on placement of the balloon, there were no effects on the respiratory or circulatory systems, nor on the general condition of the dogs. Following removal of the balloons, immediate bronchoscopy and subsequent direct examination of the autopsy specimens showed no bleeding points.

In order to test the completeness of occlusion, dyes were injected through the suction side of the tube into the bronchus distal to the balloon. Several mixtures were used, including Sudan III in mineral oil, India ink in mineral oil, and brilliant green. All specimens were removed *in toto* following the operations and the bronchi split open; in none of the specimens was dye present in any of the bronchi except the obstructed one. That the occlusion was com-

plete was also indicated in another way: within a few minutes after applying suction to the obstructed lobe, air ceased bubbling through the water trap, showing that none was leaking around the balloon.

During each operation, tests were made to determine the holding power of the balloon in the bronchus. Excessive manipulation of the lobes failed to dislodge the balloon. Nothing short of a forceful pull on the double lumen catheter succeeded in dislodging it.

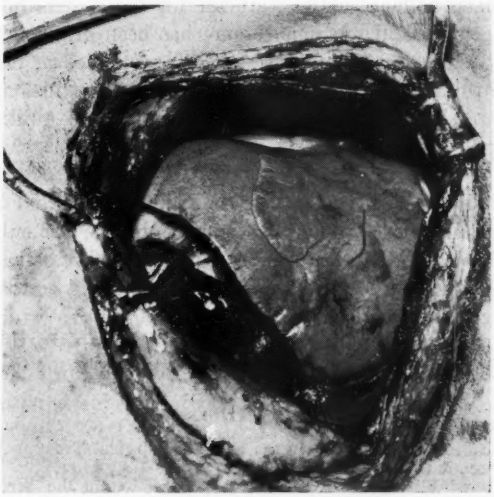

Fig. 4.—Photograph taken during an operation with balloon in left lower lobe bronchus; note atelectatic lower lobe and inflated upper lobe.

The limits of safety of the balloon were carefully studied. Attempts to break the balloon by overinflation while in place in the bronchus were unsuccessful; with the pressure increased to well over 400 mm. of mercury, the only noticeable effect was a slight dilatation of the bronchus and a bulging of the balloon into the lobe bronchi. None of the balloons were broken in this manner, although they had been used repeatedly. Deliberate efforts to break the balloon by trauma in the operative field failed.

The balloon was under complete control at all times, and its state of inflation and the completeness of occlusion could be quickly checked by noting the manometric pressure. It was found that the balloons required a pressure of 90 to 100 mm. of mercury for inflation; when in place in the bronchus, sufficient water (10 to 15 c.c.) was injected to raise the pressure to 200 mm. of mercury. Thus a pressure of 100 mm. of mercury was exerted on the wall of the bronchus. The pressure in the balloon is more than sufficient to hold the points of the holding apparatus in the bronchial wall, and since the resistance of the strips of this apparatus to bending is very slight there is very little hindrance to inflation of the balloon.

The small size of the catheter minimizes the interference with anesthesia as far as bulkiness is concerned; there is sufficient space left in the ordinary endotracheal tube to insert a small suction catheter should there be any secretions in the lower trachea. Local bronchial anesthesia may be used to lessen irritation and consequent cough stimuli. The fact that the pus is localized outside of the anesthetic field more than compensates for other minor interferences.

SUMMARY

A double-lumen balloon suction catheter for the control of bronchial secretions during lobectomy and pneumonectomy has been described. Its successful use in twenty-two lobectomies and five pneumonectomies in dogs demonstrates that (1) no harmful effects are produced, (2) complete occlusion of the bronchus is obtained, (3) dislodgement during operation is very unlikely, (4) a wide margin of safety is present, and that (5) there is little interference with anesthesia.

Clinical trials are now under way and will be reported later. It should be understood that this instrument has been designed for use only in pneumonectomies or lower lobectomies and not for use in upper lobectomies. Experimental studies are now being carried out on a similar instrument constructed primarily for use in upper lobe resections.

The authors wish to express their great appreciation to Dr. Deryl Hart, Professor of Surgery, Duke University School of Medicine, for his constructive criticism and interest in this problem.

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THORACOGASTRIC FISTULA AND MULTILOCULAR EMPYEMA COMPLICATING POST-TRAUMATIC DIAPHRAGMATIC HERNIA

GEORGE N. J. SOMMER, JR., M.D., TRENTON, N. J., AND WALDO O. MILLS, M.D., BOSTON, MASS.

IN A paper presented at the 1946 meeting of The American Association for Thoracic Surgery, Lindskog and Lawrence[2] described two patients with diaphragmatic hernia following crushing injury to the thorax. Both patients had come under their care following the introduction of intercostal tubes into the herniated stomachs. Diagnoses of left sided empyemas had been made erroneously. In one case an empyema had developed following the drainage. Both patients were successfully treated with necessarily complicated operative procedures. In a careful review of the literature the authors were unable to find similar instances of diaphragmatic hernia and thoracogastric fistula following blunt injury of the thorax and surgical mistreatment. Clopton[1] had reported the case of a child with an eventration of the left hemidiaphragm. The patient had had a rib resection and tube drainage of the stomach through the greatly elevated diaphragm prior to coming under the care of Clopton. In this case thoracic wall and extrapleural abscesses were present. This patient also recovered.

During the recent war, penetrating and perforating thoracoabdominal wounds were frequently complicated by gastrointestinal injuries. At the time of primary operative treatment, the small intestinal and gastric wounds were customarily closed and wounds of the colon were exteriorized. Shaw,[3] who was working in a thoracic center, treated patients with thoracogastric fistulas. In these instances the repaired diaphragmatic and gastric wounds had broken down, and the hernias had followed. The patients were admitted to the thoracic center for further care.

Among the 511 patients admitted to a thoracic center* in England during 1944-1945 was one with a condition very similar to those reported by Lindskog and Lawrence.[2] In this instance it is possible that a gastric fistula was caused by a needle aspirating an hemothorax following a crushing injury of the thorax.

A 27-year-old sergeant was crushed against a brick building Nov. 15, 1944, by a large army truck, which had started in reverse by mistake. He suffered severe contusions of the thorax and was admitted to a hospital shortly after the injury. Red blood cells were present in the urine, but no further evidence of renal injury became apparent. A diagnosis of tension pneumothorax was made. After the removal of 550 c.c. of air from the left pleural cavity, the intrapleural pressures were reduced from plus 10 and plus 4 cm. of water to plus 4 and zero. Sanguineous fluid was aspirated from the left pleural cavity November 17, 18,

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19, and 22; 180 to 480 c.c. were obtained. Air was removed with the fluid November 20, and again December 5.

The patient was admitted to the center December 6. He was dyspneic and presented the general signs of infection. Roentgenographic examination (Fig. 1) showed the heart displaced to the right by the intrathoracic stomach and pneumothorax. The left tenth and eleventh ribs were fractured. Barium was given by mouth December 7. To the great surprise of the observers, the barium meal flowed rapidly from the uppermost portion of the stomach into the pleural cavity (Figs. 2 and 3).

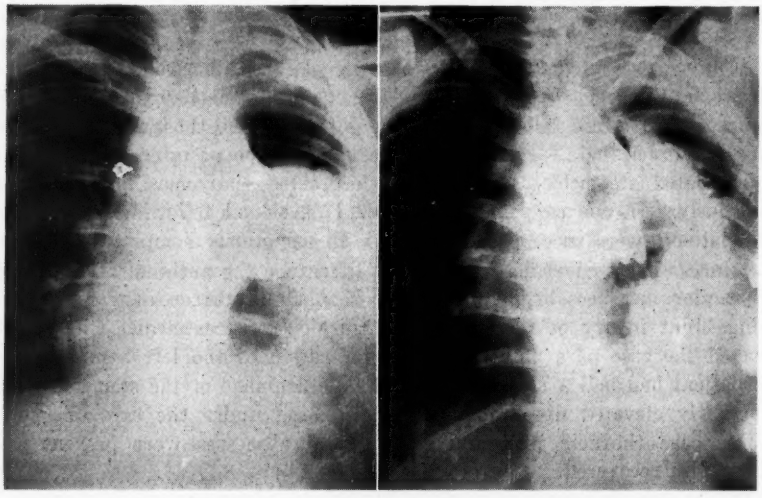

Fig. 1. Fig. 2.

Fig. 1.—Posteroanterior roentgenogram showing the heart displaced to the right by the intrathoracic stomach and pneumothorax.

Fig. 2.—Anteroposterior roentgenogram following ingestion of barium meal, which is seen in the stomach and free in the pleural cavity.

On December 8, with endotracheal ether anesthesia (Major Lawrence J. Schuhmacher, Jr., Medical Corps) the left thoracic cavity was opened through the bed of the resected ninth rib. The spleen, which lay posteriorly, was incised when the pleural cavity was opened. Brisk hemorrhage occurred, which was controlled only after ligation of the splenic vessels and removal of the organ. A large pocket of thick white pus lying on the diaphragm had been covered by the spleen. A segment of the eighth rib was removed to permit better exposure of the intrathoracic contents. The stomach was adherent to the posterior parietal pleura (Fig. 3) and displaced the lower pulmonary lobe upward. The omentum lay anteriorly against the pericardium, from which it was freed by blunt dissection. After the stomach was mobilized, the perforation 2 cm. in diameter was closed with two rows of fine silk Lembert sutures. The omentum, stomach, and the left lobe of the liver were then replaced into the abdomen. The diaphragmatic tear, which extended from within 2 cm. of the thoracic wall to the esophageal hiatus, was closed with overlapping by two rows of interrupted silk sutures. The multilocular empyema filled with thin sanguineous pus and barium, which had covered the stomach, was then broken down. The upper portion of the lower pulmonary lobe and the upper lobe were covered with plastic exudate, which had to be removed before the lung would expand. The thoracic wall was closed with interrupted sutures. Drainage of the pleural cavity was provided with a large rubber tube and water

seal. A segment of the eleventh rib had been removed for insertion of the drainage tube. During the operation whole blood transfusions were given.

The patient's immediate postoperative course was stormy. Drainage of the pleural cavity was inadequate since the lung expanding posteriorly blocked the drainage tube leaving a large anterior air pocket. Fortunately the lung became adherent in the midthorax laterally and gradual re-expansion occurred aided by voluntary breathing exercises. Penicillin was given for some days in doses of 40,000 units every four hours. Several blood transfusions were necessary. The roentgenogram April 10, 1945 (Fig. 4), showed apparent complete re-expansion of the lung. The shadow at the base represented, however, a basilar empyema. April 23, the eighth rib was resected and a small empyema was dependently drained. At this operation four heavy silk sutures were removed from the diaphragm. In addition to hemolytic *Staphylococcus aureus,* which had also been cultured at the time of the first operation, *Aerobacter aerogenes* was grown. The cavity closed satisfactorily and only a small track remained at the time of the transfer of the patient to the United States June 2. He was in good physical condition with excellent thoracic respiratory movements.

Fig. 3.

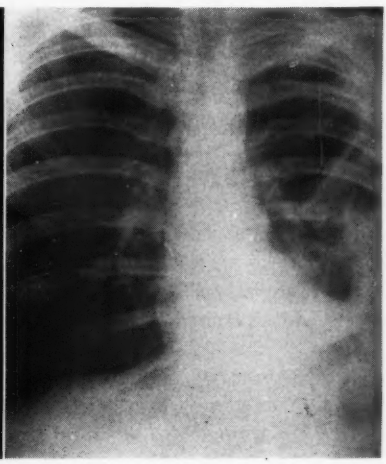

Fig. 4.

Fig. 3.—Left lateral roentgenogram after ingestion of barium meal; the stomach is seen lying posteriorly in the thorax with the barium passing superiorly and anteriorly.

Fig. 4.—Posteroanterior roentgenogram April 10, 1946, showing the re-expanded lung with evidence of basilar empyema pocket.

The case presents several lessons in the treatment of empyema thoracis. The abdominal organs, which had been intimately associated with the pus in the thorax, were restored to the abdomen without peritonitis developing; adequate penicillin therapy probably made this possible. More complete decortication and mobilization of the lung with the use of two or three intercostal drainage tubes would probably have facilitated complete and rapid expansion of the lung. The authors[4] found that more than one drainage tube was necessary after decortication. The advisability of using fine silk sutures for the repair of the diaphragm was well shown by the discovery of heavy silk sutures when the empyema was redrained.

SUMMARY

A case of thoracogastric fistula with multilocular empyema complicating a post-traumatic diaphragmatic hernia is reported. Diaphragmatic hernia must be considered following thoracic wounds and injuries and care must be used in aspirating or draining the pleural cavity following such injuries. In the reported case, aspiration may have caused the gastric perforation and the empyema.

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AMYLOID DISEASE OF THE LUNG TREATED BY PNEUMONECTOMY

Report of a Case

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AMYLOID disease localized to the lower part of the respiratory tract appears to be an exceedingly rare condition and one which heretofore has not been recognized as a surgical disease of the thoracic organs.

GENERAL CONSIDERATIONS

Amyloidosis, or the presence of diffuse amyloid deposits in certain organs or tissues, has been widely studied and described in the past sixty years. Rokitansky is credited by Wichmann[1] with describing the microscopic and gross characteristics of the condition and with distinguishing for the first time amyloid deposits as a pathologic entity from other lesions of the organs concerned. As it is commonly used, "amyloidosis" refers to the multiple, abnormal, hyalinelike, intercellular deposits or collections, in the parenchyma of the liver, spleen, kidneys, adrenal bodies, and occasionally in other areas of the reticuloendothelial system, of an atypical protein substance which stains more or less specifically. In addition, these lesions are associated with or are secondary to a prolonged suppurative process and certain other primary disturbances, such as syphilis, Hodgkin's disease, and various types of leucemia. The lesions are most commonly seen among patients who have chronic pulmonary tuberculosis with cavitation or chronic suppurative osteomyelitis.

In recent years an increasing number of descriptive reports of unusual amyloid deposits have appeared. The deposits have been said to be either generalized or localized in other than the usual or characteristic locations, such as the spleen, liver, kidneys, or adrenal bodies. These observations have been referred to by many authors as indicative of "atypical amyloidosis."[2-4] Since the clinical picture was for the most part bizarre or simulated other more commonly recognized disturbances, the true nature of the pathologic process in most of the earlier cases was identified only by microscopic examination. In only a few cases was the true condition suspected before necropsy; the amyloid depositis were considered by some workers to be merely interesting incidental observations. In addition, there was a remarkable absence of a primary suppurative or debilitating disease which could be considered as the etiologic factor in the production of these deposits of amyloid substance.

Lubarsch[5] recognized this unusual or atypical form of amyloid disease and suggested the following criteria to distinguish it from the usual or typical forms: (1) an almost complete absence of amyloid substance in the organs

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most often involved in typical amyloidosis, such as the liver, spleen, and kidneys; (2) the presence of amyloid substance in organs and parts not usually involved by the process, such as the heart, skin, and lungs; (3) the occasional occurrence of tumorlike nodules of amyloid substance; (4) the frequent failure of the deposits to react to specific stains or tests for amyloid; and (5) the absence of a preceding or concomitant disease to which the presence of amyloid might be attributed. After review of many of the reported cases of the unusual forms of the condition, Reimann and associates,[6] in reporting another case, discussed the clinical, gross and microscopic features of the so-called atypical forms and suggested the following classification of amyloidosis: (1) primary (atypical or systematized); (2) secondary (typical); (3) tumor-forming (single or multiple, localized); and (4) amyloidosis occurring in association with multiple myelomas. These authors collected thirty-five cases of primary amyloidosis, in seventeen of which the distribution was more or less generalized. In the remainder, the process was localized largely to one or two organs. As a result of their study, Reimann and associates were able to observe certain rather distinct characteristics of each of the four aforementioned forms, although there was a tendency toward overlapping in certain cases. They pointed out, further, that whereas tumor-forming amyloidosis may be a type of primary amyloidosis, yet in several cases it was sufficiently localized from a clinical and pathologic viewpoint to warrant consideration aside from the generalized group. Subsequent writers[7, 8] have endorsed this classification. Several examples of all the four types previously mentioned herein have been added to the literature since the classification of Reimann and associates was made.[4, 9-11]

As indicated by the increased number of reported cases of localized amyloid "tumors," it would seem justifiable to consider as members of a separate group those patients in which the amyloid disease is apparently entirely localized to a certain organ or tissue or to a portion thereof. Additional examples of the latter were reported by New and Erich[12] and by Figi,[13] who recognized localized sessile, polypoid, or infiltrated masses of amyloid substance in the laryngeal or subglottic tissues unassociated with demonstrable deposits of amyloid substance in other parts of the body. Corbitt and associates[8] reported on a patient whose condition had been diagnosed preoperatively and who was successfully treated by segmental resection of tissue affected by localized amyloid disease involving a portion of the wall of the urinary bladder.

It is apparent that localized amyloid disease is a very unusual process but one which can be considered for surgical management when it is deemed suitable. In the known cases of this form of the disease, the respiratory tract and skin appear to be the commonest sites of involvement.

New,[14] in 1919, studied and discussed the clinical and pathologic features of amyloid lesions of the upper air passages. In 1938, New and Erich[12] reported the clinical aspects and method of treatment in eighteen cases of the localized amyloid tumors of the larynx. The clinical features of these lesions were sufficiently characteristic to warrant recognition; the presence of these masses altered laryngeal or glottic functions to such an extent as to warrant treatment. Surgical management was utilized to eradicate these nodular deposits.

On the other hand, we have encountered only three published reports[15-17] of localized amyloid disease of the lower part of the respiratory tract. In the case reported by Balser the condition was discovered at necropsy; there was marked tracheobronchial stenosis involving the lower portion of the trachea and major bronchi, associated with a secondary emphysematous, pneumonic, and bronchiectatic process which extended throughout both lungs. Symptoms had been present for nineteen years. There was a dense and rigid deposition of amyloid substance in the walls of the lower part of the trachea and of the bronchi and the lumens of both the trachea and bronchi were markedly narrowed. In Glockner's case, asymptomatic amyloid tumors involving the larynx, trachea, and large bronchi were discovered at necropsy, but no embarrassment of the lower part of the respiratory tract had occurred and no secondary processes were noted in the lungs. The only other pathologic observations of note in this case were a urethral stricture, benign prostatic hyperplasia, and cystitis. In Meyer's case, multiple nodules of amyloid substance of various size were scattered throughout both lungs, and appeared to be continuous with the bronchial wall in certain areas, but bronchial stenosis was not present. There were degenerative processes, but no deposits of amyloid substance were present in other organs. In addition, there was no evidence of a primary disease to which the amyloidosis could be attributed.

The following report of a case is presented as one of unusual interest. It is believed to be the first reported case in which localized amyloid disease involved the major bronchi and corresponding pulmonary vessels at the hilum of one lung, and the first in which pneumonectomy was successfully accomplished.

CASE REPORT

Clinical and Surgical Aspects.—A white man 35 years old, a welder by trade, registered at the Mayo Clinic on Jan. 10, 1946. He complained chiefly of cough of nine years' duration and of daily hemoptysis of a week's duration. He was admitted directly to a hospital for study. He said that in 1937 he had noted some pain of a pleuritic nature in the right side of the lower part of the thorax, without associated fever. In addition, morning cough, productive of purulent, occasionally blood-streaked sputum, had developed. Shortly after the onset of this illness he had been admitted to a hospital for observation and treatment. Bronchograms had been made, and the diagnosis of chronic bronchiectasis of the right lung had been made. Since that time symptoms had consisted of recurrent attacks of chronic, moderately productive cough, usually precipitated by "colds" and often associated with fever and chills and pleuritic pain. Sputum continued to contain occasional traces of blood. In 1940, more bronchograms had been made; the same condition had been found. The left lung had been found to be normal. In 1942, the patient had experienced a single, moderately severe episode of hemoptysis (approximately a cupful, or about 240 c.c.). No change in symptoms had been noted until a week before admission to the clinic, at which time acute coryza had developed, followed by a marked increase in the severity of the cough and in the amount of sputum raised. During the week prior to admission the sputum had been constantly bloody. The patient had become most apprehensive and insomniac from the fear of fatal hemoptysis. There had been no recent loss of weight or significant general weakness.

The patient's systemic history was noncontributory. He smoked about ten cigarettes a day. The general history was not significant. The patient's mother had died of tuberculosis at the age of thirty-five years. When we saw the patient on Jan. 10, 1946, he did not appear to be ill and did not exhibit evidence of a debilitating disease. The temperature was 99.6° F. (37.6° C.) and the pulse rate was 90 beats per minute. Results of examination

Fig. 1.—*a*, anteroposterior view of the thorax, showing diffuse density in the field of the lower part of the right lung; *b*, anteroposterior view, showing poor filling of the hyparterial branch of the right bronchus.

of the head and neck were negative except for the presence of bloody mucus in the pharynx. Diminished breath sounds and fremitus were noted over the base of the right lung as high as the sixth rib posteriorly, and up to the level of the fifth rib anteriorly. Rhonchi and coarse râles also were elicited in this area. Blood pressure expressed in millimeters of mercury was 118 systolic and 70 diastolic. Results of the remainder of the physical examination were within normal limits. Stereoroentgenograms of the thorax revealed that diffuse, highly reactive pneumonitis involved the lower lobe of the right lung, probably on the basis of bronchiectasis (Fig. 1, *a*). The value for hemoglobin was 14.4 Gm. per 100 c.c. of blood. Erythrocytes numbered 4,080,000, and leucocytes, 13,200, per cubic millimeter of blood. The sedimentation rate of erythrocytes was 58 mm. in one hour (Westergren). Urinalysis showed the urine to have a specific gravity of 1.032 and to be normal so far as the content of albumin, sugar, and abnormal microscopic elements was concerned. The reaction of the flocculation test for syphilis was negative. On two occasions results of examination of sputum were negative for acid-fast organisms. On one occasion bacteriologic studies of the sputum revealed a green-producing streptococcus.

During the first days of this patient's hospitalization, he continued to cough up small amounts of bloody sputum. Bronchoscopic examination was performed on Jan. 14, 1946, during which a large blood clot was encountered in the bronchus of the lower lobe of the right lung. Although an obstructing lesion of the bronchus of the lower lobe of the right lung was suspected in the interpretation of stereoroentgenograms of the thorax, it was felt that the abnormal roentgenologic picture could be explained on the basis of hemorrhage into the bronchus of the lower lobe of the right lung, producing spotty diffuse densities in the fields of the lower part of the lung. No attempts at removal of tissue for biopsy or at removal of the clot were made because of the recent active bleeding. Bronchograms revealed the left lung and upper lobe of the right lung to be within normal limits. Unsatisfactory filling of portions of the bronchi of the middle and lower lobes of the right lung was encountered (Fig. 1, *b*). This was thought to be due to either an obstructing lesion or intrabronchial clots. A tentative diagnosis of chronic bronchiectasis of the lower lobe of the right lung, with secondary pulmonary hemorrhage, was made preoperatively, and right lower lobectomy was advised.

Since the bleeding subsided during the period of observation and immediate surgical intervention was not indicated, the patient was allowed to return to his home for a short period prior to operation, so that evacuation of the iodized oil might take place. He returned for surgical treatment on Feb. 18, 1946. He stated that additional bleeding or symptoms had not occurred since his last visit, and indicated that he felt well. He was hospitalized again and prepared for thoracotomy by the administration of penicillin by nebulization and intramuscularly.

On Feb. 21, 1946, with the patient under the influence of nitrous oxide and ether administered intratracheally, the right part of the thorax was explored through a primary right posterolateral incision. A segment of the right seventh rib was removed. After the pleura had been opened, the lung was found to be densely adherent to the thoracic wall and to the diaphragm over almost all of the surface of that structure. This part of the lung was dissected free with difficulty. It was seen that there was only a partial fissure between the upper and lower lobes. Dissection was carried as far as the hilus with the view of performance of lobectomy, but induration and distortion were so extensive in the hilus that further attempts to free the lower lobe of the right lung were not deemed advisable. Furthermore, in the right hilar region a firm tumor mass was discovered, which at palpation seemed to be too hard for carcinoma but did not simulate calcified tuberculous lymph nodes. It was decided to perform pneumonectomy. Transection of the hilar structures at the proximal edge of the tumor mass was done and each vessel was doubly ligated. The end of the bronchus was closed with a single row of interrupted silk sutures and the stump was covered with pleura. There was a little oozing from a number of points in the wall of the chest where adhesions existed, but this was controlled with stick ties and ligatures. The right phrenic nerve was severed for permanent interruption. The operative site was washed with solution of sodium chloride and an antiseptic agent (zephiran chloride). The

wound was closed in layers. Plasma to the amount of 750 c.c. and 200,000 units of penicillin were left in the right pleural space. Blood was transfused to the patient several times during the procedure. Immediately after the operation, bronchoscopic examination revealed the bronchial stump to be in good condition. The branches of the left bronchus were comparatively clear, and were aspirated with ease. The patient was returned to his room in good condition except for slight hypotension.

Fig. 2.—Hilum of the right lung: *a*, location of the right pulmonary artery; *b*, lateral wall of the right bronchus below the level of division between the upper and lower lobes; *c*, posterosuperior division of the bronchus to the lower lobe; *d*, course of the bronchus to the lower lobe; *e*, cut surface of bronchial wall and amyloid mass, showing peribronchial infiltration.

After the operation, results' of repeated urinalyses were negative for Bence-Jones proteinuria and the result of the intravenous Congo red test for amyloidosis was similarly negative. On the fourth and twelfth postoperative days, examination of the blood revealed mild leucocytosis and moderate secondary anemia. A blood smear disclosed an increase in regeneration of erythrocytes, with moderate toxic changes and occasional myeloid immaturity of the leucocytes. The result of the differential count was: 20 per cent lymphocytes, 4 per cent monocytes, 75 per cent neutrophiles and 1 per cent eosinophiles. The value for total serum protein was 6.4 Gm. per 100 c.c. of serum. The albumin-globulin ration was 1.6:1.

The postoperative course of the patient was uneventful. Aspiration of air and fluid from the right pleural space was performed as indicated. Postoperatively, oxygen was administered continuously for three and a half days, and penicillin was injected intramuscularly, in amounts of 120,000 units daily, for twelve days. The temperature of the patient increased gradually to 102.2° F. (39° C.) on the third postoperative day, but subsided. The patient became completely afebrile on the seventh postoperative day. He was allowed to be up on the eighth day after the operation and was dismissed from the hospital on the fourteenth postoperative day. Roentgenograms of the thorax made postoperatively revealed the usual sequel of pneumonectomy—hydropneumothorax on the right. The patient remained afebrile, however, and was dismissed from the clinic in satisfactory condition on March 11, 1946 (eighteenth postoperative day).

Two months postoperatively the patient's attending physician advised us by letter that there was marked abatement of all symptoms, that hemoptysis had not occurred, and that the patient had resumed full activity.

Gross Pathologic Aspects.—The specimen consisted of the entire right lung and approximately 0.8 cm. of the right bronchus. The external surface of the lung, with the exception of the posterosuperior portion of the upper lobe, was covered with shaggy fibrous and fibrinous adhesions. The lung itself, and particularly the middle and lower lobes, was firmer than normal. Weight of the fixed specimen was 670 Gm.

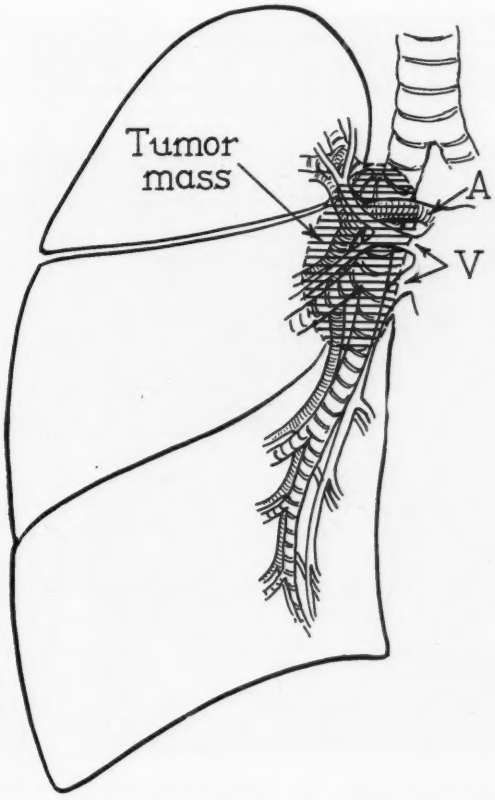

Fig. 3.—Representation of the position of the amyloid infiltration in relation to hilar structures.

At the hilus there was a hard, irregular, infiltrating, whitish-yellow mass about the bronchus, the right pulmonary artery, and the inferior pulmonary vein (Figs. 2 and 3). The infiltrating, dense tumefaction extended laterally and inferiorly into the lung substance about the bronchus to the middle lobe for a distance of approximately 3 cm. and about the bronchus to the lower lobe for 5 cm. A sharp line of demarcation was present between the mass and the surrounding lung tissue. Very little involvement of the eparterial branch of the main bronchus was noted. Not more than 2 to 3 mm. of narrowing of the lumens of the main bronchus or its branches were noted in the surgical specimen. While the mass was being sectioned, it was found to be extremely resistant to cutting; it had a consistency like that of leather. Small flecks of calcified material were identified in the substance of the mass. When the bronchus and its branches were opened, the infiltration was seen to be grossly confined to the walls of the branches to the middle and lower lobes, the proximal portions of the dorsal and ventral extensions of these branches, and a short distance prox-

imally on the main bronchus. The right pulmonary artery was included in the infiltrative process about the main bronchus. The thickness of the infiltration of the walls of the main bronchus reached 2.5 cm. in the region of the pulmonary artery. Several slightly enlarged lymph nodes were present in the hilus, but they did not appear to be abnormal. Tincture of iodine applied to the cut surface of the tumor did not give the characteristic gross color reaction for amyloid.

The remainder of the parenchyma of the lung peripheral to the mass exhibited the picture of a scattered pneumonic process throughout the middle and lower lobes of the lung. Evidence of diffuse bronchiectasis was not found, although a few scattered sacculated bronchioles containing thick, brownish, stringy exudate were noted in the middle and lower lobes.

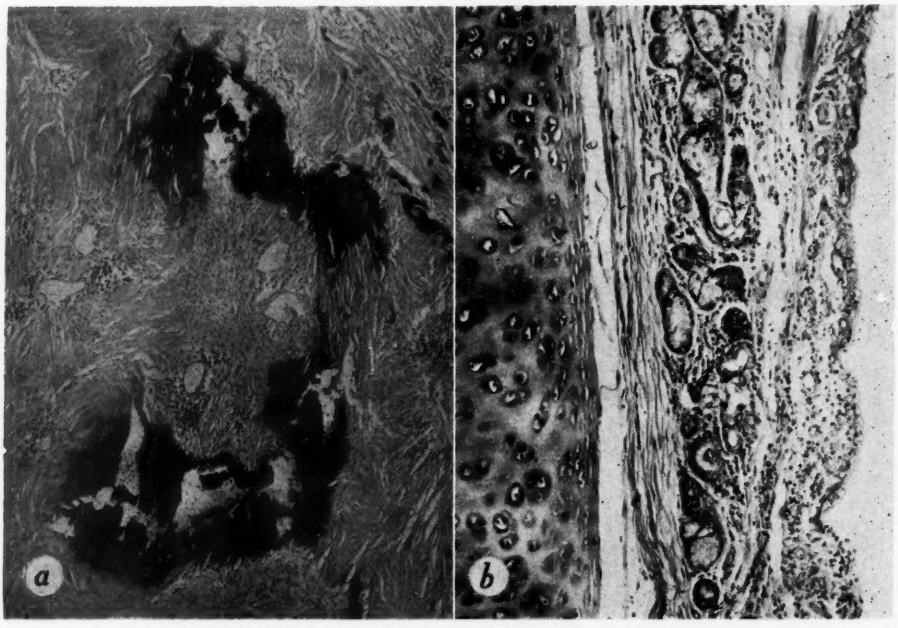

Fig. 4.—*a*, amyloid substance, with areas of calcification (hematoxylin and eosin ×60); *b*, bronchial epithelium and subepithelial structures in an involved portion of the bronchus; note the loss of ciliated stratified epithelium and replacement by single layer of cuboidal type of cells (hematoxylin and eosin ×100).

Histopathologic Aspects.—Sections through the walls of the bronchus and its branches extending into the tumor mass stained with hematoxylin and eosin showed the external coats of the main bronchus, its branches, and the surrounding connective tissue to be the seats of the pathologic process. The cartilaginous rings were intact. The dense, infiltrating mass which surrounded the bronchus and its branches and the pulmonary vessels at the hilus consisted of interlacing bundles of strongly eosinophilic homogeneous material which was very acellular and avascular. Scattered throughout were nests of inflammatory cells, consisting mainly of plasma and round cells, and lymphocytes. No giant cells were noted, although a few groups of fat-filled histiocytes were identified. Calcification of the homogeneous material was present throughout; it occurred both in small flecks and in masses of sizes up to 2 mm. (Fig. 4, *a*). The walls of the larger blood vessels were not abnormally thickened, but between the elastic fibers some of the homogeneous acellular material was seen. The changes in the mucosa of the main bronchus and its branches were limited largely

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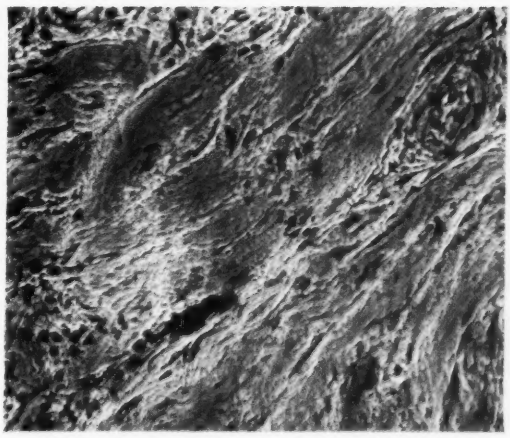
A.



B.

Fig. 5.—*a*, portion of the wall of a large branch of pulmonary artery and adjacent connective tissue involved by intercellular deposits of amyloid (methyl violet ×60); *b*, portion of the infiltration, showing lipoid degeneration of masses of amyloid (Sudan IV ×260).

to the epithelium. Over the sites of deposits of amyloid material, the stratified ciliated epithelium was replaced by a single layer of flattened, cuboidal, nonciliated epithelial cells (Fig. 4, *b*). Mucous glands and muscle appeared to be normal; only a few inflammatory cells were present in the subepithelial stroma.

Special staining of numerous sections through the involved bronchial walls, surrounding infiltration, and parenchyma of the lung was carried out with Congo red, methyl violet and Sudan IV stains. The hyalinlike intercellular material noted in the infiltrated regions previously described exhibited a lack of uniformity in staining reaction, whether it was stained with methyl violet or Congo red. When methyl violet was used, the color changes varied from gray to faint violet to brilliant violet; when Congo red was employed, the contrast in color between the amyloid substance and collagen was not uniformly distinct. Nevertheless, there were many portions throughout the sections which gave a diagnostic picture when each of these stains was used. The walls of the large arteries and veins exhibited irregular regions of amyloid infiltration, and in a few the entire wall stained characteristically for amyloid with methyl violet (Fig. 5, *a*) or Congo red. The smaller arterioles and veins in the mass were uniformly involved, as determined by the staining reaction. In fresh frozen sections many of these interlacing hyalinlike bundles appeared to contain numerous tiny, clear droplets. With the Sudan IV stain it was readily seen that these were fat-containing droplets within the bundles of intercellular amyloid material (Fig. 5, *b*). This phenomenon was seen in many places throughout the entire mass.

Sections of the parenchyma from beyond the gross limits of the tumor mass as stained with hematoxylin and eosin, revealed a scattered, irregular, lobular distribution of a chronic exudative pneumonic process in the lower lobe and to a slightly less extent in the middle lobe. Near the hilar area, moderately chronic interstitial fibrosis and cellular infiltrations were seen. The alveoli of the lower lobe contained many macrophages filled with blood pigment.

The peripheral terminal bronchioles for the most part showed slight if any dilation, but mild inflammatory changes were present in the mucosa. A few of the medium-sized bronchioles exhibited mild-to-moderate dilatation, with associated intraluminal exudation and moderate peribronchial inflammatory infiltrations and fibrosis. The parenchymal blood vessels were essentially normal. Special staining of the parenchyma of the lung for amyloid substance revealed none, in either the alveolar or bronchiolar walls or blood vessels outside the gross region of tumefaction.

Lymph nodes situated at the hilus were uninvolved by the amyloid deposition, and showed only inflammatory changes with anthracosis.

COMMENT

Localized amyloid disease, particularly in the respiratory tract, can be responsible for sufficient alteration in the anatomy and physiology of the involved structures to be of clinical importance. In this case the clinical picture was essentially that of an intermittent, long-standing, low-grade, obstructing lesion of the major bronchus or its branches, at times associated with brief episodes of hemoptysis, without clinical evidence of the presence of a debilitating or suppurating disease. That the process did not produce complete or persistent bronchostenosis is evident by the absence of a significant degree of bronchiectasis or pulmonary suppuration distally. The history of the patient would indicate that some impairment of function and drainage of the middle and lower lobes of the right lung had been present for several years. It is interesting to note that relatively little anatomic narrowing of the bronchus and its branches could be demonstrated in the surgical specimen. The surgeon, however, noted at exploration that some degree of distortion of the hilus of the involved lung had been caused by the infiltrating mass, and it is likely that

this could have produced some degree of kinking which in turn would have compromised the airway of a semirigid tube, such as a large bronchial branch. Furthermore, the loss of the cilia of the surface epithelium overlying the amyloid process in the main bronchus and its branches would suggest that a physiologic obstruction to the normal flow of bronchial secretion was present. There was no evidence of bronchial ulceration when the lung was examined in the laboratory. The source of the bleeding which resulted in the symptoms or produced the clot in the bronchial branch to the lower lobe, noted by the bronchoscopist, is best explained on the basis of extravasation from small or medium-sized bronchial blood vessels, the walls of which had been largely replaced and weakened by the described amyloid deposits.

The preoperative diagnosis in this case was that of the secondary associated disturbance. The repeated hemoptysis pointed strongly to a primary lesion involving the bronchial mucosa. Since the infiltration did not involve the mucosa or subepithelial portion of the main bronchus and its branches, it would have proved futile to attempt to determine further by bronchoscopic study or biopsy the nature of this extrabronchial lesion.

Certain other clinical considerations are immediately presented when a diagnosis of amyloidosis is made. In view of the reports in the literature of involvement of the mediastinum and lungs in cases of primary generalized amyloidosis, the question arises as to whether or not this process was only one of multiple similar processes in this patient. Additional clinical and laboratory studies made postoperatively, however, did not indicate that other deposits of amyloid substance were present. The experience of other authors would indicate that additional accessible cutaneous or submucosal nodules of amyloid substance should be evident at a relatively early stage in cases of the generalized atypical forms of amyloidosis.

It is interesting to observe that roentgenograms did not suggest the hilar infiltration in this case. This is especially remarkable in view of the fact that some degree of calcification was present in the mass. Yet, on subsequent review of the stereoscopic roentgenograms and the bronchograms, a roentgenologist said that he was unable to define the primary pathologic process in the roentgenograms.

Deposits of amyloid substance in tissues frequently are described in the literature as being grayish, translucent masses which yield a characteristic color reaction when iodine is applied to their cut surfaces. In this case, the gross picture did not show the classical picture, and did not suggest a typical form of such lesions. The extremely tough, leathery consistency of the mass as noted by both the surgeon and the pathologist was of much more significance in recognition of the nature of the process. The intercellular deposits of amyloid substance seen in the microscopic sections were, for the most part, arranged into bundles and, in some places, into irregular, small masses. The significance of the lipoid deposits within many of these amyloid deposits is not apparent, but may represent, in association with the calcification, a degenerative process. Increased fibrosis and cellular infiltrations throughout indicate that inflammation undoubtedly played a significant role in the development of the lesion in

this case. Results of staining with Congo red and methyl violet, as specific stains for amyloid substance in tissues, were sufficiently positive to be confirming evidence of the nature of the intercellular material, but the variation in staining with both of these dyes was evident. This has been noted by other investigators and it has been thought that "preamyloid" or ground substances would not show the same staining characteristics as more mature amyloid. In our case it would appear that the presence of lipoid in many regions may have altered the staining properties.

In spite of several recent excellent experimental studies[18-21] on amyloidosis of the secondary type, the true nature of amyloid substance and the mechanism for its elaboration are still unknown. In recent studies, it is pointed out that the principal chemical structure of this material is that of a complex protein, probably conjugated with other proteins or polysaccharides.[22-23] Valuable additional information should be forthcoming when the chemistry of proteins is further investigated. The variation from the usual staining reaction seen in the so-called primary generalized form of amyloidosis and the tumor-forming localized form of the condition would suggest that perhaps some qualitative difference exists in the substance which is deposited in the presence of each of these entities as compared to the intercellular material present in the spleen, liver, kidneys, and adrenal bodies in the secondary form of amyloidosis. Whether the protein substance, called amyloid, is produced locally in the organs or tissues involved as a result of aberrant metabolic processes, or is deposited from the blood stream, is also undetermined. The process of chronic destruction and repair of tissue is apparent in all cases in which secondary amyloid disease is present. When experimental secondary types of amyloidosis are present, the fact that excessive stimulation with bacterial toxins and foreign proteins of the immunity mechanism of the organism plays an important role in the production of such deposits has been shown clearly by nearly all investigators. Generally speaking, therefore, amyloidosis is not a degenerative process, but is a local or generalized disturbance of protein metabolism.

No data are available to explain the factors involved in the production of amyloid deposits in tissues of mesodermal origin that are involved in either the primary generalized form of amyloidosis or in the localized amyloid "tumors." The origin of amyloid substance in the presence of these disturbances remains purely a matter of speculation regarding the role of a pre-existing inflammatory process. For example, the lower part of the respiratory tract frequently is the site of both acute or chronic inflammations, yet the apparent rarity of deposits of amyloid substance in recognizable amounts in these organs would militate against the fact that the localized form of amyloidosis is an end result of a chronic inflammatory process. Finally, further confusion is added to evaluation of etiologic factors of the production of amyloid when one considers the part played by myelomatosis in cases in which myeloma and amyloidosis coexist.

Of equal importance to the factors involved in the production of the amyloid disease is the consideration of the process of resorption of the abnormal depositis once they have occurred. That amyloid is resorbed from various organs has been observed both clinically[24-26] and experimentally[18, 19] in the sec-

ondary form of the disease. On the other hand, primary, generalized amyloidosis appears to be a progressively fatal disturbance from which no recovery has been reported. Localized amyloidosis seems to resemble more closely the primary or atypical form, so that in the presence of localized amyloidosis local resorption would not be expected to occur. Hence, surgical excision or fulguration must be the treatment of choice in the eradication of localized amyloidosis. The experience of laryngeal surgeons[13] at the Mayo Clinic has been that unless thorough excision of lesions involving the larynx and subglottic tissues is accomplished, results of treatment are indifferent and unsatisfactory.

The case we have presented is one of considerable interest in view of the increasing number of reports of localized amyloid disease for which surgical treatment has been utilized. It is hoped that this report will serve further to acquaint clinicians and surgeons with the several forms of amyloid disease, and to increase their awareness of the more atypical and localized forms. The latter, although apparently rare, can be the basis for obscure lesions in or about the lower respiratory part of the tract and, as in this case, may be amenable to some form of surgical excision. The localized form of amyloidosis also presents another entity of a sizable group of lesions for which exploratory thoracotomy is necessary if successful diagnosis, treatment, and determination of prognosis are to be achieved. At the time of surgical intervention, both the surgeon and the surgical pathologist must be sufficiently aware of the characteristics of localized amyloid disease to be able to assess properly such lesions for surgical treatment. The consistency of the tissue involved by these deposits is of diagnostic aid to the exploring surgeon, but the true nature of the process must be established by histopathologic examination. In recent months, at the Mayo Clinic, several patients who had amyloid tumors involving the larynx and urinary bladder have been encountered. In examination of such patients the endoscopist, in securing specimens of the lesions for biopsy, has been impressed by the toughness of the tissue and its resistance to cutting with ordinary forceps. With the aid of certain polychromatic stains, such as polychromatic methylene blue, the amyloid substance can be identified with relative ease in the fresh frozen microscopic section.

SUMMARY AND CONCLUSIONS

Amyloid disease, other than the commonly recognized typical form secondary to a chronic debilitating disturbance, is now being recognized as a clinical and pathologic entity. It may occur in a more or less generalized distribution or may be localized to a portion of an organ, particularly in the connective tissue elements and walls of the blood vessels of the involved structure.

Deposits of amyloid substance which form localized nodular tumors or infiltrations, although uncommon, may simulate other pathologic lesions and require surgical removal of either a portion of the organ or the entire organ.

The mechanism of elaboration of this abnormal intercellular material in localized masses is not known, and no evidence exists thus far that resorption of the deposits occurs either spontaneously or under the influence of conservative therapeutic measures.

The consistency of the involved tissues and the resistance of these tissues to cutting may be valuable diagnostic aids to the surgeon when he is dealing with unidentified masses. The staining characteristics of the amyloid substance are of considerable aid to the surgical pathologist in establishment of prompt positive identification.

A case of localized amyloid disease involving the main bronchus, its branches and the corresponding branches of the pulmonary vessels at the root of the right lung has been reported herein. Pneumonectomy was performed after thorough study in an attempt to establish the cause of the repeated episodes of hemoptysis.

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CASE OF MASSIVE CONGLOMERATE TUBERCULOSILICOSIS SIMULATING PULMONARY NEOPLASM

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THE case to be reported is that of a patient with a large intrapulmonary mass, which, although it had many of the characteristics of a neoplasm, was finally proved to be a massive conglomerate nodule of tuberculosilicosis.

In the literature we have found seven other microscopically proved cases of silicotic or tuberculosilicotic masses in which a clinical diagnosis of neoplasm had been made. There is also one not yet reported (Skavlem[10]). While others have been described, they all lack microscopic proof. The significant facts concerning these nine cases will be summarized.

CASE REPORT

The patient, P. G., a 58-year-old Polish male factory worker, consulted his surgeon, Dr. Gordon Holden, because of a poorly localized, lower right chest or upper abdominal pain of about two months' duration. There was no definite relationship of the pain to food, position, exercise, or deep breathing. The pain was accompanied by soreness across the upper abdomen as well as increasing weakness to the point of fainting, so that it was difficult for him to continue his work. Over a period of several months he had lost about 16 lbs. He gave no history of coughing, hemoptysis, or dyspnea. However, subsequent pulmonary function tests demonstrated a considerable decrease in his respiratory reserve.

Occupational History.—For a period of at least thirty years there was presumptive exposure to free silica dust. During the first ten years of this time he worked as a miner in a hard rock coal mine and for the next twenty years he was a molder in a foundry. For the last five years he worked chiefly as a factory elevator operator where there was probably no exposure to dust, but a portion of this time was spent in a sand pit used for testing machine guns.

Family History.—His father died at the age of 85 and his mother at 65, causes unknown. Three brothers, aged 70, 65, and 64, are living and well. There is no known history of cancer.

Physical Examination.—The patient was a fairly well-nourished white man of medium stature, who did not appear ill. No lymph nodes were palpable in the cervical, axillary, or inguinal regions. The chest was barrel-shaped and the right hemithorax appeared larger than the left. Expansion, although diminished, was equal on the two sides. Both hemithoraces were hyper-resonant. Over the right lower lobe posteriorly the breath sounds were more distant than elsewhere. There were no râles. Physical examination showed no other significant findings.

Laboratory Studies—

Chest roentgenograms by Dr. R. C. Hall (Figs. 1 and 2) gave the following findings:

"X-rays of the chest reveal a symmetrical thorax. The diaphragms are scalloped in appearance and are low in position. The cardiac silhouette appears normal. The lung fields are hyperventilated and there is an increase in the markings throughout the lung fields, as evidence of a fibrosis. There are also some small nodulations in the peripheral portions of the lungs. In the right lower lobe there is a dense tumor mass about 8 × 6 × 5 cm., which is in the posterior portion of the right lower lobe and, in the lateral view, overlies the spine. In the mediastinum there is a suggestive round shadow which may be a

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metastasis. Impression: tumor in right lower lobe; suggestion of metastasis to a mediastinal node; diffuse pulmonary fibrosis, which is suggestive of exposure to dust."

Bronchograms by Dr. Karl Gruppe, following bronchoscopy, showed distortion of the right lower-lobe bronchi posteriorly in the region of the tumor mass with some blocking.

Pulmonary function studies were done by Dr. George Wright, Nov. 29, 1943. Fluoroscopy showed that both diaphragms and ribs moved equally and normally. The mediastinum remained in the midline. There was no evidence of bronchial obstruction, either complete or partial, as determined by the presence of trapped air, and the tumor mass within the lung did not pulsate.

Resting minute ventilation was 10 L., and maximum breathing capacity was 84 L. Bronchospirometry results follow:

	RIGHT (%)	LEFT (%)
Minute ventilation	53	47
Oxygen absorbed	52	48
Carbon dioxide output	50	50

Blood: Red blood cells were 4,800,000; hemoglobin, 96 per cent; white blood cells, 6,200. The differential count was polymorphonuclear neutrophiles, 54 per cent; lymphocytes, 35 per cent; monocytes, 7.5 per cent; eosinophiles, 3.5 per cent; with nonfilaments, 20 per cent. Sedimentation rate was 14 mm. in one hour (Cutler method). Wassermann was negative.

Urine: The specific gravity was 1.017 to 1.025. Urine was consistently negative for sugar, albumin, casts, and red blood cells, with an occasional white blood cell.

Sputum: None was produced for examination.

Electrocardiogram was normal except for prolongation of the P-R interval.

A diagnostic bronchoscopy revealed no direct evidence of tumor. The only significant finding was some obstruction of the dorsal bronchus to the right lower lobe.

A previous bronchoscopy reported by Dr. Gruppe revealed "a suspicious thickening of the septum between the axillary segment and the basal bronchi of the right lower lobe."

Upon completion of the studies, it was concluded that the patient had a pulmonary neoplasm of undetermined type and the presence of silicosis was considered to be an incidental finding. The malignancy of the tumor was questioned because of its size, sharp outline, and apparent lack of lymph node involvement.

Pneumothorax on the right was instituted as preliminary to exploration. Four days later, on Dec. 4, 1943, the chest was opened. The lung was free except for a few adhesions, mainly to the diaphragm. The parenchyma was studded with many small hard nodules. The apex of the upper lobe was shrunken and suggested the presence of an old tuberculosis. A very firm, rounded mass, 6 or 8 cm. in diameter, was situated in the apex of the lower lobe. Because of obliteration of the major and minor fissures, it was impossible to determine the extent of invasion of the tumor. Mediastinal nodes were palpable, and although they were soft, the possibility of metastases could not be excluded. It was decided, therefore, that a pneumonectomy should be performed. This was carried out by the usual technique of individual ligation of the hilar structures and closure with interrupted silk sutures of the bronchial stump, which was then pleuralized.

Postoperatively, sterile fluid was removed from the right pleural space on a few occasions to neutralize the pressure. Except for the development of an attack of influenza on the fifteenth postoperative day, the patient's course was smooth. A sputum examination during this attack was negative for acid-fast bacilli both by direct examination and guinea-pig inoculation. He returned to his home on the thirty-fifth postoperative day.

Because of mediastinal displacement to the right and the presence of silicosis in the left lung, a two-stage thoracoplasty, right, was performed on March 23, 1944, and April 14, 1944. Since recovery from these operations he has regained his weight and strength. There continues to be some disability, chiefly because of dyspnea and also because of discomfort in the right chest.

Pulmonary function studies (Table I) were performed by Dr. Wright (1) before pneumonectomy; (2) postpneumonectomy but before thoracoplasty; (3) post-thoracoplasty.

The surgical specimen was examined by Leroy U. Gardner and William H. Carnes of the Saranac Laboratory (Figs. 3, 4, and 5) and showed the following:

Gross: There was black pigmentation, marked diffuse emphysema, and an occasional silicotic nodule from 1 to 5 mm. in diameter; there was a large, oval, 8 x 4 cm., sharply circumscribed, black, conglomerate, tuberculosilicotic mass in the hilum of the lower lobe; a discrete 5 mm. calcified nodule was in outer layer of conglomerate mass, and a completely calcified hilar lymph node.

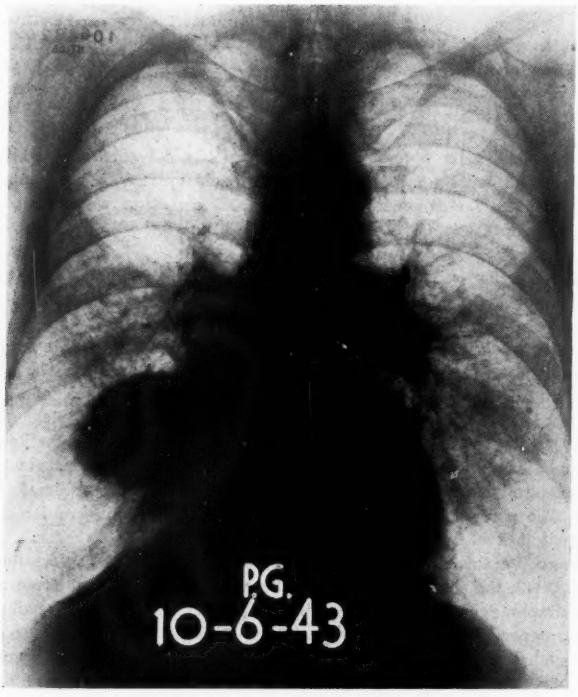

Fig. 1.—Posterior-anterior roentgenogram showing the tumor in the right lower lobe and an increase in markings throughout both lung fields.

Microscopic: There were scattered small hyalin silicotic nodules in all parts of the lung; the large mass at the hilum of the right lower lobe was a typical conglomerate lesion with some areas of granular caseous necrosis but no fresh cellular or epitheloid cell lesions; and a very occasional acid-fast bacillus was found in the caseous mass.

Diagnosis: Silicosis; conglomerate tuberculosilicotic lesion of right lower lobe; and healed calcified primary tuberculosis complex.

SUMMARY OF REPORTED CASES

In Tables II and III there is a compilation of the significant data on the nine reported cases of verified conglomerate silicotic nodules simulating neoplasm. Rendich and Camiel[9] recently reported two cases of their own and

discussed five others. Of these seven we have accepted six as proved. The other case they mentioned, one reported by Piaggio Blanco and associates,[7] has been omitted here because microscopic proof was lacking. Another case has been reported by Zech.[13]

The case here reported is number eight. In addition, Dr. John H. Skavlem[10] reported to us that late in 1943 he had a similar case in which lobectomy was performed for a tumor which on microscopic examination proved to be silicotic.

Fig. 2.—Right lateral roentgenogram showing tumor in lower lobe.

He has since written[11] that, due to personnel upsets occasioned by the war, he has been unable to date to make a more complete report. This would seem to be the ninth proved case. In addition to the reported proved cases, there may be others.[7, 13] Gardner[3] states that conglomerate lesions are common in silicosis, but that because of their bilateral or "bat-wing" appearance, together with their ill-defined outline and their appearance in lungs with widespread silicosis, the typical cases are seldom diagnostic problems.

A summary of the cases here listed reveals that the most common symptom is dyspnea, at first noted only on exertion, but gradually progressing. Loss of weight was noted in six patients. Expectoration, when noted, was scanty, and there was no record of hemoptysis.

The average age in the eight patients at the time of hospitalization was 52 years, with extremes of 34 and 73 years.

In the eight patients having pathologic examination, tuberculosis was proved in 50 per cent. In only one patient, however, were tubercle bacilli found clinically (Case 1), and then only by gastric analysis. Sputum, if present, was usually scanty. This was observed also in some of the other reported probable cases, such as those of Piaggio Blanco and associates[7] and Minet and associates.[6]

Fig. 3.—Sagittal section through right lung (natural size). The upper lobe presents the usual picture of generalized, discrete, silicotic nodulation without evidence of infection; a localized focus of emphysema is present beneath the thickened apical pleura. The middle lobe is not included in the plane of section. A large, ovoid mass can be seen occupying a portion of the lower lobe. This is bounded above by the fissure and below by its essential membrane. This "tumor" is black, hard, and rubberlike, except in places where it is undergoing caseous, softening. Mesially it includes an enlarged, calcareocaseous, silicotic lymph node which adjoins the bronchus and dislocates that structure. Elsewhere the lower lobe is free from evidence of infection. Mesially there are discrete black silicotic nodules and, in the costophrenic regions, extensive emphysema.

Bronchoscopy was performed in Cases 3, 4, 5, and 8, with negative findings. Aspiration biopsy was performed by Gut[4] in Case 5, and has been discussed by Piaggio Blanco and associates,[7] but it has not resulted in the making of a proper diagnosis in a single instance.

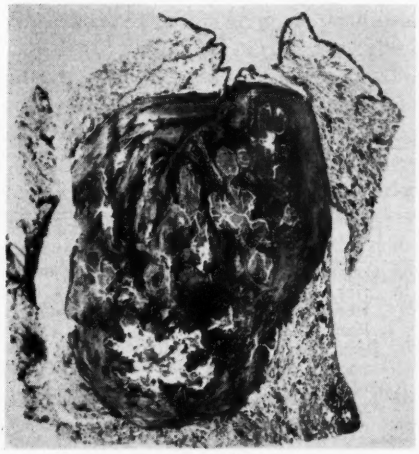

Fig. 4.

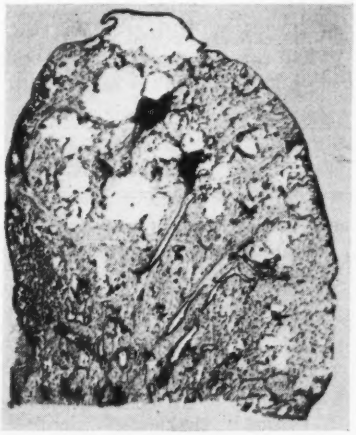

Fig. 5.

Fig. 4.—Histologic section of conglomerate lesion (magnification 1:1). This shows the sharply defined borders with absence of inflammatory reaction in the surrounding lung. The center of the mass is composed of diffuse and nodular hyaline fibrous tissue heavily pigmented with coal dust. Areas of necrosis are of lighter shade. No calcified foci are included in the plane of section.

Fig. 5.—Histologic section of the apex of the upper lobe (magnification 1:1). Emphysematous blebs can be seen surrounding two black, silicotic nodules. There are many small, discrete nodules widely scattered through the section. There is also considerable linear pigmentation in the pleura and the walls of blood vessels.

DISCUSSION

The significant fact which is demonstrated by the present case and the series of eight others briefly reviewed is the confusion which can arise in making a differential diagnosis between conglomerate tuberculosilicosis and pulmonary neoplasm. The problem of differential diagnosis is simplified when the masses are bilateral as is usually the case, and particularly when the masses occur on a background of generalized nodulation.[2] If one is fortunate enough to have serial roentgenograms over a period of years, confusion is not likely to occur. Furthermore, the behavior of the shadows in such a series is perhaps the most reliable index of activity of the process. In the presence of silicosis a conglomerate nodule is much more likely to occur than is a carcinoma.[2] On the other hand, Pohle and Ritchie[8] comment that in their case "roentgenological diagnosis of neoplasm was justifiable even in the light of post-mortem findings."

In two of the cases reviewed here (Cases 3 and 8) the masses were unilateral. This fact alone is confusing. In addition, when a case is first seen with a well-developed nodule and there have been no previous films, diagnosis may be difficult. Piaggio Blanco and his co-workers[7] report that "many cases of silicosis of the lung have been operated upon with the mistaken diagnosis

TABLE I. RESULTS OF STUDIES OF PULMONARY FUNCTION

PULMONARY FUNCTION STUDIES	PREOPERATIVE 11/27/43		POST-PNEUMONECTOMY 3/20/44		POST-THORACOPLASTY 10/13/44	
	LITERS	%	LITERS	%	LITERS	%
Maximum breathing capacity	84.		54.		55.	
Lung volume:						
Total	7.11	100	3.74	100	3.37	100
Vital capacity, available	4.98	70	2.21	59	1.88	56
Vital capacity, used	4.28	60	2.19	58.5	1.84	54.5
Mid capacity	3.54	50	2.40	64	2.09	62
Reserve air	1.41	20	.87	23	.60	18
Residual air	2.13	30	1.53	41	1.49	44.5

TABLE II. PROVED CASES OF SILICOTIC LESIONS SIMULATING NEOPLASM

CASE	AUTHOR	LOCATION	SYMPTOMS	CLINICAL DIAGNOSIS
1	Rendich and Camiel	Bilateral: right consolidation of base; left, smaller area in middle	Cough following broken ribs, loss of weight, weakness, occasional hemoptysis	Carcinoma of right lung with metastasis to left
2	Rendich and Camiel	Bilateral: right, upper; left, upper and smaller	Recurrent attacks of nocturnal dyspnea, loss of weight	Lymphoma or carcinoma of lung
3	Bradshaw and Chadoff	Unilateral: right, area size of half dollar at hilum; left, clear	Cough, loss of weight, and dyspnea for 9 mo.	Lung abscess—later, pulmonary carcinoma
4	Pohle and Ritchie	Bilateral: right, large, irregular mass into lower lung; left, smaller mass	Dyspnea on exertion and weight loss	Bronchogenic carcinoma
5	Holman and Pierson's Case #7	Bilateral: Right, round circumscribed density at base; left, large mass, base.	Numbness and weakness of legs for one year	Tumor or abscess with pneumonoconiosis
6	Gut	Bilateral: left, "fist-sized shadow" upper portion; right, smaller shadow, middle field	Dyspnea for 3 to 4 years, cough and expectoration, chest pain, loss of weight, sweats	Carcinoma of lung, either primary or metastatic
7	Zech	Bilateral: left, infraclavicular, sharply defined, oval shadow size of palm of hand; right, slightly smaller shadow present for 7 years	Increasing weakness and psychomotor instability	Bilateral lung tumor
8	Woodruff and Kelley	Unilateral: right, 8 x 4 cm. oval, sharply defined shadow, lower lobe; left, clear except for increased markings	Weakness, loss of weight, chest pain	Tumor right lower lobe, type undetermined
9	Skavlem	This patient had lobectomy for tumor which proved to be a massive silicotic lesion.		

of carcinoma and the correct diagnosis established only after the histologic study of the specimen removed." While this was true in the case reported here, as well as in that of Bradshaw and Chadoff[1] and also the one of Skavlem,[10] no others have been discovered in the literature. Zech[13] states that Conrozier and Magnier reported tumorlike shadows in thirty miners. In any case of silicosis with a coexisting discrete pulmonary shadow, a diagnosis of conglomerate tuberculosilicosis should be entertained.

The relationship between tuberculosis and silicosis is close. Gardner[3] feels that the large, conglomerate, silicotic lesions almost always show tuberculosis,

and points out the frequency with which bacilli ultimately appear after these lesions attain maturity, even though the sputum has been negative for a long time. (In the present series sputum was recorded as positive in one instance and at post-mortem examination only 50 per cent were felt to be tuberculous.)

In some instances these lesions become caseous and excavate. Such an occurrence introduces the term of "phthisis atra," a name in the older literature "used to designate cavity formation in high-grade anthracotic lungs of miners."[12] The case of Holman and Pierson[5] (Case 5, Table II) illustrates this entity. The patient was a quartz miner with marked pneumonoconiosis and bilateral cavities and, therefore, a case of "phthisis atra."

In making a diagnosis of conglomerate tuberculosilicosis, the most important factor would seem to be a history of prolonged exposure to silica. Table III shows that the actual duration of exposure is known in five patients and averaged twenty-four years. In only one case could no exposure be traced, and that fact alone would cast doubt upon the diagnosis if it were not that chemical analysis of the lung tissue revealed a tremendous increase in silica content.

Although exposure is usually prolonged, symptoms may not develop until years after exposure has ceased. Rendich and Camiel's[9] first patient had a history of 25 years' exposure, but had not been exposed for twenty-four years before hospitalization.

TABLE III. DURATION OF EXPOSURE TO DUST

CASE	AGE	DURATION OF EXPOSURE AND TYPE OF DUST	YEARS SINCE EXPOSURE	TREATMENT AND PROGRESS OF DISEASE
1	73	25 years coal dust	24	Terminal admission, no treatment
2	45	Coal miner and steel worker unknown number of years	Unknown	Terminal admission, no treatment
3	34	12 years coal dust	None (?)	Two courses of x-ray therapy followed by extension of disease bilaterally; pneumonectomy, contralateral pneumothorax, death
4	36	No history of exposure to dust	Unknown	X-ray therapy; 2 months later showed bilateral increase; additional treatments did not prevent steady decline
5	58	28 years quartz miner	Unknown	Treatment limited to accompanying anemia; death in 6 months
6	56	Several years in pottery factory	20+	Dyspnea noted 4 years before admission; condition stationary for 8 months under observation; death 3 days following admission
7	61	25 years miner in Germany (Herner Region)	10	Eight years before admission and 2 years after cessation of exposure, applied for pension as invalid; diagnosis of pulmonary tuberculosis made on physical examination, never confirmed by x-ray; no expectoration. Admitted for terminal care; irrational; no specific treatment.
8	58	10 years hard rock coal miner; 20 years as moulder in foundry	5+	Pneumonectomy; later, thoracoplasty; dyspnea more evident following pneumonectomy.
9		Facts unknown[11]		

TREATMENT

We know of no specific medical treatment beneficially affecting silicosis. Although roentgen therapy was employed in Cases 3 and 4, it was based upon the mistaken diagnosis of pulmonary carcinoma. Its use was followed by extension of the lesion in each patient. Surgery is of limited value. Most patients with fairly extensive silicosis are quite dyspneic, so that any procedure involving a sacrifice of lung tissue will necessarily increase the disability. With the present method of measuring individual lung function, it is possible to predict quite accurately the expected disability following pulmonary resection. The removal of a conglomerate tuberculosilicotic lesion by lobectomy or pneumonectomy may at times be an impossible or at least a futile procedure. In those instances where the tumor formation is unilateral and the patient's respiratory reserve is adequate, as in our case, we believe exploration and resection is indicated for two reasons. First, diagnosis is not so certain that malignancy can be excluded. This was true in our case and in case 4.[8] Second, in certain instances these tumors undergo necrosis and cavitation. It would seem desirable to prevent this if possible.

SUMMARY

A single case of conglomerate tuberculosilicotic nodule is presented, another is mentioned, and the seven previously reported cases are discussed briefly.

Whenever a lung tumor appears in a person who has been exposed to large amounts of silica, the possibility of a conglomerate tuberculosilicotic nodule should be considered.

We are indebted to Dr. L. U. Gardner and the staff of the Saranac Laboratory for the preparation and study of the pathologic material presented in this paper.

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SPONTANEOUS RUPTURE OF THE ESOPHAGUS

Report of a Case with Recovery

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SPONTANEOUS rupture of the esophagus is of rare occurrence. It is generally accepted to be fatal when it does occur. For that reason it is worth while to record the following case in which the patient went on to complete recovery. By the term "spontaneous rupture" is meant the rupture of an esophagus presumed to be previously normal.

In 1943, Klein and Grossman[7] reviewed the literature on this subject and found forty cases reported with a mortality rate of 100 per cent. Since then, Collis, Humphreys, and Bond[3] have reported one and Eliason and Welky[4] three more. None of these patients recovered.

While a great many patients with esophageal perforation due to foreign bodies or instrumentation have recovered, to date no patient with spontaneous rupture has been reported that survived. Graham,[5] in a footnote in the *Yearbook of General Surgery* for 1944, states that he has seen two patients recover after drainage of an accompanying empyema. It is doubtful if the case reported by Benson and Penberthy[2] should be included, since an esophageal ulcer was seen by esophagoscopy a few hours before rupture occurred. Clinically this case did present the same problems that would have resulted from a spontaneous rupture.

Vinson[9-11] has reported a number of cases of esophageal stricture that he felt were due to small spontaneous ruptures resulting in strictures upon healing. There is considerable justification in assuming that these strictures did form in this manner. Conceivably a number of these might have been due to incomplete ruptures.

A 42-year-old, well-developed, rather obese white male was admitted to the Herman Kiefer Hospital, Detroit, Mich., July 9, 1941. He appeared very ill. He was dyspneic at rest and noticeably cyanotic. His temperature was 102° F., respirations 34 per minute, and his pulse rate was 120 per minute and of poor quality. At the time of his entry the patient was too ill to give a satisfactory history. He had been admitted to another hospital four days earlier complaining of shortness of breath, upper abdominal pain, and pain in the left side of his chest. He had been treated with oxygen and sedatives and kept under observation. A chest roentgenogram had revealed a left pleural effusion. A thoracentesis had been performed, disclosing the presence of clear yellow fluid with no demonstrable organisms. He had then been transferred to Herman Kiefer Hospital with a presumptive diagnosis of tuberculous pleuritis with effusion.

Examination upon entry revealed a very sick man with the physical findings of a left hydropneumothorax. This was confirmed by fluoroscopy and x-ray. The patient's abdomen

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was distended and the presence of mild epigastric tenderness was noted. A left thoracentesis was performed immediately, and 800 c.c. of very foul smelling, thin, purulent, brownish fluid were removed. The removal of this fluid gave the patient but scant relief from his dyspnea and discomfort. Bacteriologic examination of the fluid revealed the presence of *Staphylococcus albus, Streptococcus viridans,* and *Bacillus influenzae.* No acid-fast organisms were found. The patient's white blood count was 19,800 per cubic millimeter with 73 per cent neutrophiles, of which 20 per cent were nonsegmented. His hemoglobin measured 74 per cent and his erythrocyte count was 3,700,000 per cubic millimeter. His urinalysis was essentially normal.

The patient was placed in an oxygen tent and given sulfathiazole by mouth. While in the oxygen tent he was fairly comfortable but became cyanotic if the tent was removed. The next day another thoracentesis removed 500 c.c. of the same type of fluid, again without giving the patient any relief.

Believing the patient had an acute putrid empyema probably secondary to a small spontaneous bronchopleural fistula of unknown etiology, a closed intercostal drainage of the left pleural cavity was performed, using 1 per cent procaine as local anesthetic. The intercostal catheter was connected to a water-tap suction maintaining a constant negative pressure of 20 to 24 cm. of water. This catheter failed to function satisfactorily because it frequently became plugged in spite of irrigations every few hours. Although the oral fluid intake measured 4,000 to 5,000 c.c. per twenty-four hours, the patient's twenty-four-hour urinary output was never more than 800 c.c. Usually it measured from 450 to 600 c.c. Clinically the patient gradually improved.

On July 29 an open thoracotomy by rib resection was performed by Dr. Norman J. Wilson, resident surgeon. A few hours later the dressings were saturated with a thin greenish material that had an odor much like fresh vomitus. While the dressings were being changed the patient drank a glass of water. Immediately the water gushed out of the thoracotomy wound. It was then obvious that the patient had a perforation of the esophagus with an esophagopleural fistula.

At this time a more complete history was obtained. The patient admitted to drinking an average of twenty to thirty bottles of beer daily, but stated that he rarely drank anything stronger. He had been subject to rare mild episodes of pyrosis that never inconvenienced him. He had noticed a slight nonproductive morning cough for ten or fifteen years.

On the evening of July 3 he had drunk several strong gin drinks, after which he became nauseated and vomited twice. Both times the vomitus contained fresh blood. He immediately developed a constant epigastric pain which apparently was not very severe. He soon felt ill and went to bed only to find he was dyspneic upon lying down although fairly comfortable sitting up. The next day (July 4) he drank fifteen to twenty glasses of whiskey and soda. Later in the day he again felt very ill but could be comfortable only in the sitting position. Early in the morning of July 5 he suddenly became extremely dyspneic and began to have increasingly severe pain in the epigastrium and the left side of his thorax. He then called a physician who sent him to a hospital.

As soon as the diagnosis of rupture of the esophagus was made, all food and fluid by mouth was discontinued and he was given only parenteral fluids. The advisability of doing a gastrostomy or inserting a nasal feeding tube was discussed but it was decided to observe him for a longer period of time. He seemed to be quite comfortable and continued to improve. Four days later (August 2) he vomited a small amount of fresh blood and shortly afterward passed several pints of dark clotted blood per rectum. He rapidly went into shock. He was given several whole blood transfusions within a few hours and his condition improved. No further massive hemorrhages occurred. A soft rubber nasal feeding tube was passed into his stomach and hourly feedings given through this. After a week the patient objected so strenuously to the tube that it was removed. Methylene blue given by mouth still appeared on the thoracotomy dressings a few seconds after being swallowed. He was given a soft diet and although a fair percentage of the ingested food escaped from the thoracotomy wound this seemed to be lessening daily. By September 9 there was no evidence of an esophagopleurocutaneous fistula.

At this time acid-fast organisms were found in his sputum on three occasions. An overexposed roentgenogram of the chest revealed a two cm. cavity in the apex of the partially re-expanded left lung. Subsequent sputum smears and cultures failed to reveal any acid-fast bacilli. Also subsequent roentgenograms of the chest did not disclose any cavity.

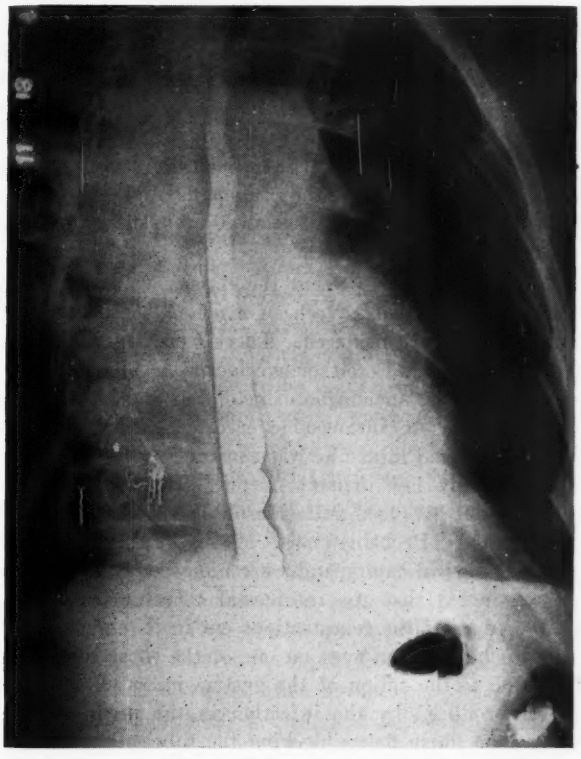

Fig. 1.—Reproduction of roentgenogram (retouched) illustrating the partial esophageal filling defect which was present after the rupture healed.

The patient continued to improve slowly and by November the empyema space was entirely obliterated. A full diet was not only tolerated very well but was demanded by the patient. On November 13, barium studies of the esophagus disclosed no stricture but there was noted a 1½ inch irregular partial filling defect on the left anterolateral wall of the distal esophagus just proximal to the cardia (Fig. 1). This was interpreted by Dr. C. C. Birkelo, radiologist, as representing scar-tissue formation secondary to the rupture. Subsequent studies five months later showed this defect to be unchanged. The patient was entirely asymptomatic at this time and has remained so. Three years later (July, 1945) he was traced and interviewed. He stated he had remained in excellent health and had no pain, dysphagia, or discomfort. It was not possible to convince him of the advisability of more x-ray studies of his esophagus.

Most commonly, the patient with a rupture of the esophagus is a male between 35 and 45 years of age who has been a heavy drinker. After an episode of forceful vomiting, with or without hematemesis, he is seized with a sudden

agonizing upper abdominal or substernal pain so severe that the usual dosages of morphine give no relief. An important observation is the early but rather transient presence of subcutaneous emphysema in the neck and upper anterior chest wall. There may be considerable upper abdominal tenderness and muscular spasm. Soon there is evidence of a left hydrothorax or hydropneumothorax. Roentgenograms of the chest may reveal mediastinal emphysema or even a mediastinal fluid level if the infection remains localized to that area. Very soon, however, roentgenograms will disclose a pleural effusion, usually on the left side. The patient is acutely ill and in the course of a few hours goes into a state of vascular collapse from which he rarely recovers. The diagnosis of a spontaneous rupture of the esophagus could be quickly and easily confirmed by watching the course of a swallow of barium mixture with the patient behind the fluoroscopic screen.

While this patient did not present the classic symptoms of rupture of the esophagus, the diagnosis might have been made much sooner if the possibility of this condition had been considered. There were several details during this patient's early illness that were either overlooked or to which too little importance was ascribed. First, an adequate history of the onset of the illness was not obtained. This was an inexcusable error. Second, even though he was receiving an adequate fluid intake he was constantly thirsty, mildly dehydrated, and had an abnormally low urinary output. He received large dosages of sulfathiazole orally but his blood sulfathiazole levels were usually too low to be accurately determined. Probably most of his oral fluids and medications passed into his left pleural cavity and were removed by the intercostal suction-drainage. It was noted that the intercostal catheter became roughened and soft and that the edges of the fenestrations cut in it tended to become everted. This latter point could be seen even on one of the chest roentgenograms. This may have been due to the action of the gastric juices on the tube, although it could have been produced by the infection in the pleural space. What was thought to have been fibrin flakes blocking the tube might have been food particles or coagulated milk.

Had the pleural fluid been analyzed for the presence of gastric juice the diagnosis would have been obvious from the first. On four occasions[1, 6, 8, 14] the diagnosis of rupture of the esophagus has been made during life by this procedure.

Eliason and Welky[4] have recently reported three fatal cases of spontaneous rupture of the esophagus and have admirably reviewed the theories as to etiology and discussed the usual clinical and autopsy findings. Apparently the inciting cause is a sudden increase in intraesophageal pressure, brought on by forceful vomiting, straining, or external trauma to the abdomen or thorax. In practically all cases coming to autopsy a linear tear is found in the esophagus just proximal to the cardia. Associated with this are variable degrees of mediastinitis and left pleuritis. Sometimes the esophagus ruptures directly through the left parietal pleura where it is in intimate contact with the lower esophagus. On other occasions a mediastinitis results first with a concomitant

left pleural effusion which soon becomes purulent as the mediastinal infection invades it. Whether or not pre-existing pathologic changes must be present in the esophageal wall before rupture can occur has not been satisfactorily settled.

The reason these patients die so quickly is still unexplained. Unquestionably, the sudden forceful onslaught of chemical and infective mediastinitis and pleuritis is the most important factor. Just what effect this produces on the adjacent sympathetic nerves and plexuses is largely conjecture. The patient may survive the first few days, if the infection is not overwhelming, only to succumb to a massive hemorrhage from the site of rupture when he seems to be on the road to recovery.

Because the condition is so rare and so few cases have been diagnosed during life, the literature contains but few recommendations as to therapy. Williams and Boyd[15] suggested early thoracotomy drainage. This is also suggested by Vinson.[12] Benson and Penberthy[2] reported a case of rupture of an esophageal ulcer into the pleural cavity treated by closed drainage of the empyema and the patient recovered. Eliason and Welky[4] recommend posterior mediastinotomy. This would appear to be the procedure of choice if the infection were limited to the mediastinum. If an empyema is present, the author recommends a closed intercostal drainage preferably with constant suction. This would tide the patient over his initial toxicity. When his condition had improved sufficiently and when it was felt that the mediastinum was well fixed, an open thoracotomy drainage should be done.

Surgical repair of the esophagus following spontaneous rupture has been attempted but once.[3] In this instance the patient expired twenty-one hours after operation. This is truly a formidable procedure to perform on a desperately ill patient, and, to be successful, would have to be done within a few hours after the rupture had occurred when an accurate diagnosis is most difficult. It would seem that these early hours might better be spent in attempting to resuscitate the patient by means of sedation, oxygen, parenteral fluids, and transfusions, with surgery limited to simple drainage of the infected region.

In the light of our present knowledge of chemotherapeusis the administration of penicillin in large dosages is definitely indicated. At the same time, one of the sulfonamide salts given intravenously might be a worth-while adjunct to penicillin. The efficacy of these drugs of course depends entirely upon the bacterial flora present.

Esophagoscopy is not recommended. Therapeutically it offers the patient nothing. There is real danger of further traumatizing friable inflamed esophageal tissues by its use. Observing a swallow of barium sulfate mixture under the fluoroscopic screen would give the same diagnostic aid as esophagoscopy with none of the disadvantages of the latter.

The use of a nasal feeding tube is open to strong criticism because of the possibility of producing further injury by the passage of the tube and the irritation the tube would theoretically produce by residing over the site of rupture.

Possibly these dangers are not as great as they might seem. If it is used, a chest roentgenogram should be taken immediately after passing the tube to determine its position. Vinson[13] has reported a case in which the tube was visualized looped outside of the esophagus into the mediastinum.

Whether or not a gastrostomy or jejunostomy should be done for feeding purposes is a moot question. Again this is a major operative procedure for a critically ill patient. Probably those patients who survive the first few days would recover without it if a fatal hemorrhage did not intervene. The patient could well be supported during the initial few days with fluids given intravenously and subcutaneously. As soon as the patient's condition permits, it is recommended that a jejunostomy be performed. This would place the esophagus at rest as much as is possible while at the same time providing a means of supplying much needed nutrition. This is much to be preferred to a gastrostomy, as it would obviate the danger of a reflux of food through the rent in the esophagus. In a few cases coming to autopsy it was noted that the esophageal rupture extended into the stomach. It thus seems advisable to keep the stomach as empty as possible as well as the esophagus.

It would be well to have compatible blood kept in readiness in a "bank" or refrigerator so that it might be administered with no delay if a hemorrhage occurs. The danger of this secondary hemorrhage is greatest during the first week or two. If the blood is ready and instantly available, its use may well prevent a fatality.

If the patient recovers, he should be checked at intervals of a few weeks or months by means of barium studies of the esophagus because of the possibility of subsequent stricture formation. If a stricture did occur, treatment could be started early before obstruction intervened.

With the exception of the two cases mentioned by Graham,[5] this is the first case to be reported of recovery following spontaneous rupture of the esophagus. If the entity of rupture of the esophagus is borne in mind, many more cases should be diagnosed before death. Undoubtedly the mortality rate will always be high, but if the diagnosis can be made early enough and prompt treatment begun, more and more patients should recover.

CONCLUSIONS

1. A case is presented in which the patient recovered following a spontaneous rupture of the esophagus.

2. Certain recommendations and suggestions as to diagnosis and treatment are discussed.

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HORNER'S SYNDROME AND HYPERABDUCTION NEUROVASCULAR SYNDROME FOLLOWING INTRAPLEURAL PNEUMONOLYSIS

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THE following case report is presented because of the occurrence in a single patient of two rare complications of intrapleural pneumonolysis.

CASE REPORT

A 39-year-old white male was admitted to the hospital on April 24, 1944, with a history of pulmonary tuberculosis discovered three years before. Roentgenograms of the chest showed extensive, exudative-fibrotic changes in the left apex and first and second costal interspaces. Phreniclasia, left, was performed on May 19, 1944. The operation was brief and uneventful. Pneumoperitoneum was induced on the following day. Following these procedures, no changes were noted in the eyes or extremities, neither postoperatively nor in a careful general re-examination on Aug. 16, 1945. The radial pulse was counted with equal ease in either wrist, both by members of the staff and by the patient himself. Beginning, however, in November, 1945, it was noted that the left radial pulse became increasingly difficult to feel, finally becoming impossible to detect. The patient had no discomfort and noted no other differences in the left arm. Artificial pneumothorax was induced on the left on March 22, 1945, and pneumoperitoneum was discontinued in October, 1945.

Because of the persistence of positive cultures of gastric washings and because of x-ray evidence of an area of uncollapsed, diseased lung held up by adhesions, an intrapleural pneumonolysis was undertaken on June 17, 1946. A broad adhesion was seen extending from the apex of the left upper lobe to the upper posterior chest wall, at the level of the first rib. Lung tissue extended to within 0.5 cm. of the chest wall. The site was injected with procaine solution through a long needle under direct observation through the cannula. The adhesion was divided, with some difficulty and some pain, close to the chest wall. In so doing, a small intercostal vessel was opened, which was subsequently sealed with the cautery. The operation lasted seventy-five minutes.

During the operation the patient's left arm was held in a position of anterolateral hyperabduction. After about twenty minutes, he began to feel numbness, paresthesias, and electric-shocklike sensations radiating down the arm to the finger tips. These became very severe but abated rapidly after the operation. The immediate postoperative course was uneventful.

On June 26, 1946, the patient experienced a feeling of pressure in the left chest and fainted. Physical and x-ray examination revealed accumulation of fluid in the left chest. Five hundred cubic centimeters of bloody fluid were aspirated, another 500 on June 29, and 400 more July 2.

Ten days after the operation the patient began to have bouts of increasingly severe pain, first in the heel of the left hand and wrist, later spreading to the volar and medial aspects of the forearm. These came on especially at night, were often associated with relative pallor and coolness of the left hand, "pins-and-needles" sensations, tremors, and local weakness. The pain became excruciating and was described as a feeling of the muscles of the forearm being "crushed and twisted." Analgesics and opiates gave only partial relief. Diathermy did not help.

A few days later it was noted that the left pupil had become much smaller than the right and the left eyelid drooped. There was a slight enophthalmos. Anihidrosis was not

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apparent. Further examination revealed absence of the subclavian, brachial, and radial pulses on the left. Blood pressure in the right arm was 120/80. On the left it was not obtainable, though fine oscillations of the mercury column were observed at 90 mm. The right palm and hand were moist, but on the left there was no sweating and the palmar skin was shiny and atrophic. Muscular weakness and some atrophy were evident in the entire left upper extremity. Repeated venous pressure studies, by the direct method, were normal on the right (5 cm. of blood), exceptionally low (2 cm. of blood) on the left. The "hand exercise test," which has been used to detect venous obstruction,[1] was negative bilaterally.

A trial injection of 30 mg. of papaverine intravenously produced no detectable change or subjective benefit. Ergotamine, 0.5 mg. intramuscularly, neither aggravated nor alleviated the symptoms. In time, the pain became somewhat localized in the lower part of the left biceps muscle. It was still very severe, and the patient was despondent. He noted that sitting up in bed and leaning on his elbows gave him a little relief, while dropping the shoulders aggravated the discomfort.

Abatement of symptoms was very gradual. By October 20 the pain and paresthesias were entirely gone, and great improvement in muscle strength was obvious. The left arm was still pulseless. The left hand appeared as warm and pink as the right, but on hyperabduction only the left quickly blanched. The palmar skin on the left was still shiny, relatively dry, and atrophic. The myosis had improved and had an intermittent character. At times the pupils were equal or the left actually larger than the right. The ptosis was slightly less marked. Enophthalmos and anhidrosis were not apparent.

DISCUSSION

The syndrome now known as Horner's was first described in 1858 by Claude Bernard, who produced it in rabbits by section of the cervical sympathetic nerves. Horner, in 1860, described a similar clinical picture in man. We have not found Horner's syndrome listed among the complications of intrapleural pneumonolysis in the textbooks. That it may follow accidental surgical injuries of the neck is well known,[2] but it has not been described as complicating intrapleural pneumonolysis, except in a few foreign communications and one report in the American literature. Hanrich, Bouvrain, and Roche[3] described four cases. They point out that nerve fibers from the ciliospinal center in the medulla pass into the anterior branches of the first three dorsal nerves and thence into the stellate ganglion and cervical sympathetic structures. Vieussen's nerve, which carries fibers innervating the iris, unites the middle and inferior cervical ganglia or the inferior cervical and first thoracic ganglia. These investigators believe that during a high intrapleural pneumonolysis the stellate ganglion, Vieussen's nerve, or communicating branches may be injured. Cavalcanti and Almeida[4] also describe two cases. They conclude that the occurrence of Horner's syndrome in their cases is explained by ascent of heat radiated from the cautery during difficult section of apical adhesions. In all cases reviewed, the syndrome was observed immediately after pneumonolysis and disappeared or subsided within a few weeks.

Kross[5] reported three cases of permanent Horner's syndrome, two following thoracoplasty with Semb apicolysis and one following an intrapleural pneumonolysis that presented no technical difficulties. The latter case was also complicated by intense subcutaneous emphysema, and the acute onset of the syndrome was at the time attributed to mechanical pressure, since "it is difficult

to conceive of a direct injury to the ganglia or chain from manipulation in the pleural cavity, however near the apex that might have been." However, although the subcutaneous emphysema subsided, the Horner's syndrome was permanent. (The position of the adhesions sectioned in Kross' case appears to have been similar to that in our patient, in whom subcutaneous emphysema was not, of course, a factor.) Kross raises the question, since the same technique was employed in approximately 150 other patients without complication, "whether in these three instances, the apparently injured portion of the sympathetic nervous system may not have been situated outside of its usual location and thus within the area of the operative field, subjecting itself to unavoidable trauma." This is perhaps the most likely explanation of all, though one that is scarcely susceptible to direct proof.

Both the French[3] and Brazilian[4] papers also reported vasomotor disturbances, viz., vasodilatation of the involved half of the face and upper extremity. Such phenomena are inconstant constituents of the Horner's syndrome and by no means comparable to the severe vasospastic reaction seen in our patient. To explain the latter we believe we must invoke another mechanism, i.e., the neurovascular syndrome produced by hyperabduction of the arms as described by Wright,[6] who discussed at length the differential diagnosis and the anatomic mechanism which produces this syndrome. Wright recommended "that special attention be paid to the state of the pulse and complaints of paresthesias and numbness from patients whose arms are in hyperabduction on operating tables. . . ." However, four of his five cases were the result of prolonged, habitual sleeping in the supine position with the arms hyperabducted, and the fifth patient had an injury involving the shoulder. Our patient stated that up until the time of the pneumonolysis he could sleep in almost any position and only rarely assumed a prone position with arms hyperabducted above the head. After the operation he acquired the habit of sleeping only on his back, with arms folded across his chest, or else on his right side.

Wright presented data in his paper to demonstrate that occlusion of the subclavian artery by hyperabduction of the arms is a normal phenomenon which occurs with varying ease. In our patient the radial pulse on the right can be made to disappear very easily indeed, by simple elevation of the arm to 180°. We believe that prolongation of such occlusion at the time of operation, in an arm of which the circulation was already subnormal (due to some unknown cause) contributed to the damage done.

We have found one additional instance of the hyperabduction neurovascular syndrome in the literature. Paull's[7] case was also the result of sleeping in the prone position with arms hyperabducted above the head.

SUMMARY

1. Neurologic and vascular syndromes caused by a functional mechanism (hyperabduction of the arms) in the absence of anatomic anomalies have been described by Wright[6] and by Paull.[7]

2. A case is reported following intrapleural pneumonolysis, during which the arm was held in anterolateral hyperabduction.

3. The patient also exhibited a Horner's syndrome, a rare sequela.

4. Improvement in both conditions has been spontaneous but very slow.

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THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

Twenty-Seventh Annual Meeting
May 28-30, 1947, Hotel Jefferson
St. Louis, Mo.

Program

Wednesday Morning, May 28, 1947

9:00 A.M. BUSINESS MEETING

9:30 A.M. SCIENTIFIC SESSION

1. **Dorsal Sympathetic Ganglionectomy for Intractable Asthma**
   Duane Carr and (by invitation) J. Hughes Chandler
2. **Experiences With a New Method for the Control of Intrathoracic Aneurysms**
   Osler A. Abbott
3. **Anteriovenous Fistula of the Lung**
   Herbert C. Maier and (by invitation) Aaron Himmelstein, Richard L. Riley, and Joseph J. Bunim
4. **Resection of a Coarctation of the Aorta Followed by Subclavian-Aortic Anastomosis: Report of a Case**
   Howard Bradshaw
5. **Aortic-Pulmonary Anastomosis for Pulmonary Stenosis**
   Willis J. Potts (by invitation)

Wednesday Afternoon, May 28, 1947

2:00 P.M. SCIENTIFIC SESSION

6. **Diseases of the Esophagus: Moving Picture Demonstration of Esophagoscopic Views**
   Paul H. Holinger and (by invitation) Albert H. Andrews, Jr.
7. **Surgical Management of Carcinoma of the Lower Two-Thirds of the Esophagus and Cardiac End of the Stomach**
   John W. Strieder
8. **Congenital Esophageal Atresia and Tracheoesophageal Fistula**
   Clayton G. Lyon and (by invitation) Stanley G. Johnson
9. **Esophageal Hiatal Hernias of the Short Esophagus Type: Etiologic and Therapeutic Considerations**
   A. M. Olsen (by invitation)
10. **Controlled Respiration in Transpleural Operations**
    Frederick R. Mautz, Claude S. Beck, and (by invitation) Harold F. Chase

Thursday Morning, May 29, 1947

9:00 A.M. SCIENTIFIC SESSION

11. **The Diagnosis and Operability of Bronchiogenic Carcinoma**
    John H. Gibbon, Jr., Louis H. Clerf, and (by invitation) Peter A. Herbut, and John J. DeTuerk
12. **Cancer of the Lung: Relationship of Topographic Features to the Interval and Late Results of Operation**
    Harold Neuhof and Arthur H. Aufses
13. **Carcinoma of the Lung**
    Ralph Adams
14. **The Treatment of Inoperable Bronchiogenic Carcinoma by Methyl-bis**
    Edward F. Skinner (by invitation), Duane Carr, and (by invitation) William E. Denman

15. **Nonmalignant Lesions of the Lung Simulating Bronchiogenic Carcinoma: Report of Thirty Cases**
Lyman A. Brewer, III, and (by invitation) Wilfred M. G. Jones, and Frank S. Dolley

Thursday Afternoon, May 29, 1947

2:00 P.M. EXECUTIVE SESSION, HOTEL JEFFERSON

3:00 P.M. SCIENTIFIC SESSION

Address of the President
I. A. Bigger

16. **Pulmonary Edema: Experimental Observations on Dogs Following Acute Peripheral Blood Loss**
Robert M. Eaton (by invitation)

17. **The Effect of Pulmonary Inflation and Deflation Upon the Maintenance of the Circulation**
Samuel Alcott Thompson

18. **The Regeneration of Defects of the Trachea and Bronchi: An Experimental Study**
Rollin A. Daniel, Jr.

19. **An Improved Method of Resection of Pulmonary Segments: Report of a Technique Used in Over Sixty Cases of Bronchiectasis**
Richard H. Overholt, R. H. Betts, and (by invitation) F. M. Woods

7:00 P.M. COCKTAIL PARTY, HOTEL JEFFERSON

8:00 P.M. BANQUET, HOTEL JEFFERSON

Friday Morning, May 30, 1947

9:00 A.M. SCIENTIFIC SESSION

20. **The Place of Exploratory Thoracotomy in the Management of Intrathoracic Disease**
John B. Grow and (by invitation) Martin L. Bradford

21. **Chronic Nonspecific Suppurative Pneumonitis**
W. E. Adams and (by invitation) Richard Kirshner

22. **Pulmonary Resection for Chronic Abscess of the Lung**
Robert R. Shaw and (by invitation) Donald L. Paulson

23. **Pulmonary Resection for Chronic Lung Abscess**
Edward M. Kent and (by invitation) Frank S. Ashburn

24. **The Effect of Chemotherapeutic Agents on the Growing Tubercle**
Robert G. Bloch and (by invitation) Kirsten Vinesland, Robert H. Ebert, and Erwin Levin

25. **Closed Intrapleural Pneumonolysis: An Analysis of 1,000 Consecutive Operations**
J. Claude Day and (by invitation) Paul T. Chapman and E. J. O'Brien

26. **Preliminary Anterior Chondrocostectomy Combined With Closed Cavity Drainage and Posterior Thoracoplasty**
Edward S. Welles and Joseph Gordon

Friday Afternoon, May 30, 1947

2:00 P.M. BARNES HOSPITAL

1. **Presentation of Five-Year Cures of Bronchiogenic Carcinoma**
Evarts A. Graham

2. **Malignant Mixed Tumors of Bronchus and Malignant Pulmonary Cysts**
Nathan A. Womack

3. **Diagnosis of Bronchiogenic Carcinoma by Sputum Examination**
Thomas H. Burford and Hans Wandall

4. **New Chemical Factors Modifying the Growth of the Tubercle Bacillus**
   Ben Eiseman
5. **Hereditary Features of Pulmonary Arteriovenous Fistula**
   Alfred Goldman
6. **Studies in Anoxia and Oximetry**
   James O. Elam
7. **Studies on Pulmonary Infarction**
   John Smith and Masauki Hara
8. **Motion Picture Demonstrating Pulmonary Capillary Circulation**
   Duff S. Allen

Erratum

In the article by Sommer and Mills entitled "Hemothorax and Empyema in a Thoracic Center" in the April, 1947, issue of the JOURNAL, Figs. 11 and 12 on page 168 were in inverted position.